POWER

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The Reward

AW-DON'T WORK SO HARD, SMITTY.
SAY, MR. SMITH, CAN YOU GIVE ME A JOB FIRING?
CHIEF ENGINEER
Suggested By J. E. Brigham, Somerville, Mass.

Of all sad words, these are most sad—
"Here is the job I might have had."

Conway Building Power Plant--I

By Thomas Wilson

SYNOPSIS—A 1,200-kw. direct-current plant carrying a combination elevator, power and lighting load from a single set of busbars. Voltage regulation is within 2 per cent. Generator circuit-breakers and field rheostats and the engines are under remote control from a special bench board. The plant is unusually well provided with indicating and recording instruments and a good system of records in which operating expenses are properly distributed between the various departments.

The Conway, one of the finest office buildings in the City of Chicago, has recently been completed by the Marshall Field Estate. It is situated at the southwest corner of Washington and Clark St., just opposite the Cook County Courthouse and City Hall. The building, Fig. 1, is practically square in plan, extending 187 ft. along Clark and 197 ft. along Washington St., and is 21 stories and attic in height. It is of the most modern type of fireproof steel construction and rests upon a caisson foundation extending 100 ft. below street level to bedrock. The first floor is devoted to shops and to the rotunda, the latter measuring 76 ft. in each direction and extending two stories in height, the entire area being covered with a skylight 32 ft. above the first floor. The inclosing walls of the rotunda are of terra cotta, the corridors of the building are faced with white marble, and the interior finish throughout is the finest grade of selected mahogany.

Below the street level is the basement, which is given over to storerooms and quarters for the help, such as the elevator employees and janitors. There are shower baths, locker and wash rooms, a rest room, and what is more unusual in a building of this character, a gymnasium, Fig. 2, which the employees are invited to use during off hours. On the same floor is the engineers' office, which is conveniently located so that the engineer at his desk can look over the engine room in the sub-basement or can step out to a runway over the boilers, from which the header valves are accessible, or to a runway back of the boilers, from which the oil tank for the generating units, hot water heaters and expansion tank can be reached. In addition, stairways lead to both engine and boiler rooms, so that the engineer may have ready access to each. The office contains a vault for storing supplies and the engineers' reference files. It also has a lavatory with shower baths and toilet, faced with marble and fitted up to correspond with the rest of the building.

The lighting load on the power plant embraces in one-unit fixtures throughout the building, about 15,000 lamps, which give a total connected load of 750 kw. The power load consists of 212 hp. in motors for driving pumps, fans and the coal- and ash-handling equipment. There is 600 hp. more in elevator motors. The following estimate of the load that might come upon the plant at any one time has been made: For 75 per cent. of the lighting, 590 kw.; for the maximum requirements of the elevators, 400 kw.; and for miscellaneous power, 120 kw.; making a total of 1,110 kw. The average daily load expected is about half this total.

Sixteen passenger elevators of the 1-to-1 gearless traction type serve the building. Each is equipped with a 35-hp. motor and at a speed of 500 ft. per min. the capacity of each car is 2,750 lb. In addition there is a freight elevator of the double-worm-gear electric-traction type having a capacity of 3,000 lb. at a speed of 350 ft. per min. and a maximum capacity of 6,000 lb. at slow speed. A sidewalk lift of one-ton capacity completes the elevator equipment.

The building is heated by a two-pipe vacuum system drawing exhaust steam from the generating units. There

FIG. 1. EXTERIOR VIEW OF THE CONWAY BUILDING

is a total of 80,000 sq.ft. of direct radiation and 5,000 sq.ft. of indirect surface for heating the air supplied to the entranceways, basement and sub-basement. The toilets, boiler and engine rooms, basement, sub-basement and entranceways are ventilated. To them a total of 104,000 cu.ft. per min. of fresh air is supplied. The exhaust fans have a capacity of 88,500 cu.ft. per min. All fresh air to the basement and sub-basement is washed, but the air to the engine and boiler rooms is simply passed through cloth filters. In all there are seven fans, each directly driven by a motor. Except the fresh-air fan for the entrances, which is under thermostatic control, there is no automatic regulation of speed.

To conform with the building it serves, the engine room, Fig. 3, was made unusually attractive. A red-flint-tile floor with black border is accentuated by wains-

coting of white terra cotta. The wall above is faced with white enamel brick and the ceilings are painted white. The engines are painted dark green, with highly polished trimmings and railings of steel tubing. A large gage board, a feeder board of black Monson slate and special generator panels and bench board all add to the general attractiveness of the engine room.

As the average load, even on dark winter days, is not expected to exceed 600 kw., units have been installed to conform with this capacity. The largest is a 600-kw. machine driven by a 24&40x42-in. cross-compound engine at 100 r.p.m. There are two other units; one, a 400-kw. machine driven by a 24x42-in. engine having the same speed as the larger unit, and the other a 200-kw. generator driven by a simple Corliss 16x36-in. engine at a normal speed of 125 r.p.m. As is usual with slow-speed machines of this type, the engines are massive and capable of withstanding years of service at a low cost for upkeep. In the order of their capacities the engines weigh 234,000, 136,000 and 63,000 lb., respectively. As a single machine is expected to carry both the elevator and lighting loads, special attention was given to regulation. Sensitive governors were employed, and the flywheels were made considerably heavier than usual, the respective weights being 76,000, 56,000 and 25,000 lb. At present the plant is running at about one-third of the estimated normal load, and with swings from 400 to 1,100 amp., regulation within 2 per cent. is maintained.

With an initial pressure of 150 lb. gage and a back-pressure of 3 lb., the guaranteed water rate for the smallest engine at full load is 22 lb., and at half load, 23.5 lb. per i.hp.-hr.; for the engine of intermediate size the rates are 22 and 23.5, and for the largest engine, 20 and 24 lb. respectively.

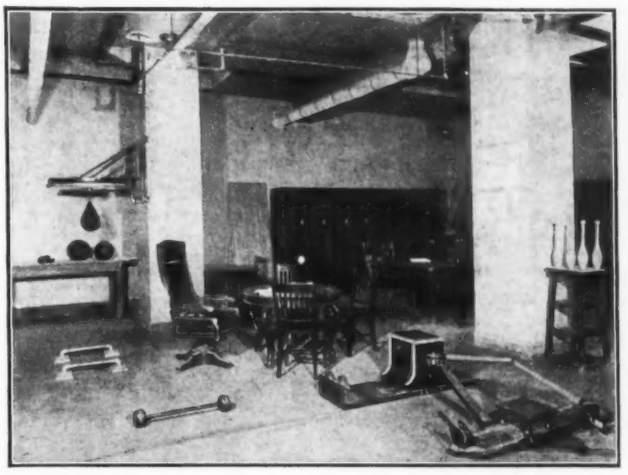


FIG. 2. GYMNASIUM FOR EMPLOYEES IN BUILDING

The current is generated at 230 volts and by using balancers is distributed on three-wire circuits, the lighting being supplied at 110 volts and the motors at 220 volts. To this there is one exception. The lights in the engine room take current at 220 volts from the machine side of the circuit-breakers, so that even if the breaker is out there will still be light in the engine room. It is the intention to run the 200-kw. machine from 6 p.m. to 7 a.m. and on Sundays, while the 400-kw. unit will handle the load from 7 a.m. to 6 p.m. On dark and winter days the 600-kw. generator will carry the day load.

Each engine has an automatic electric stop set to trip at 10 revolutions above normal speed. The stop may also be tripped and the engine shut down by push-buttons on the control board. Each engine has a reducing mo-

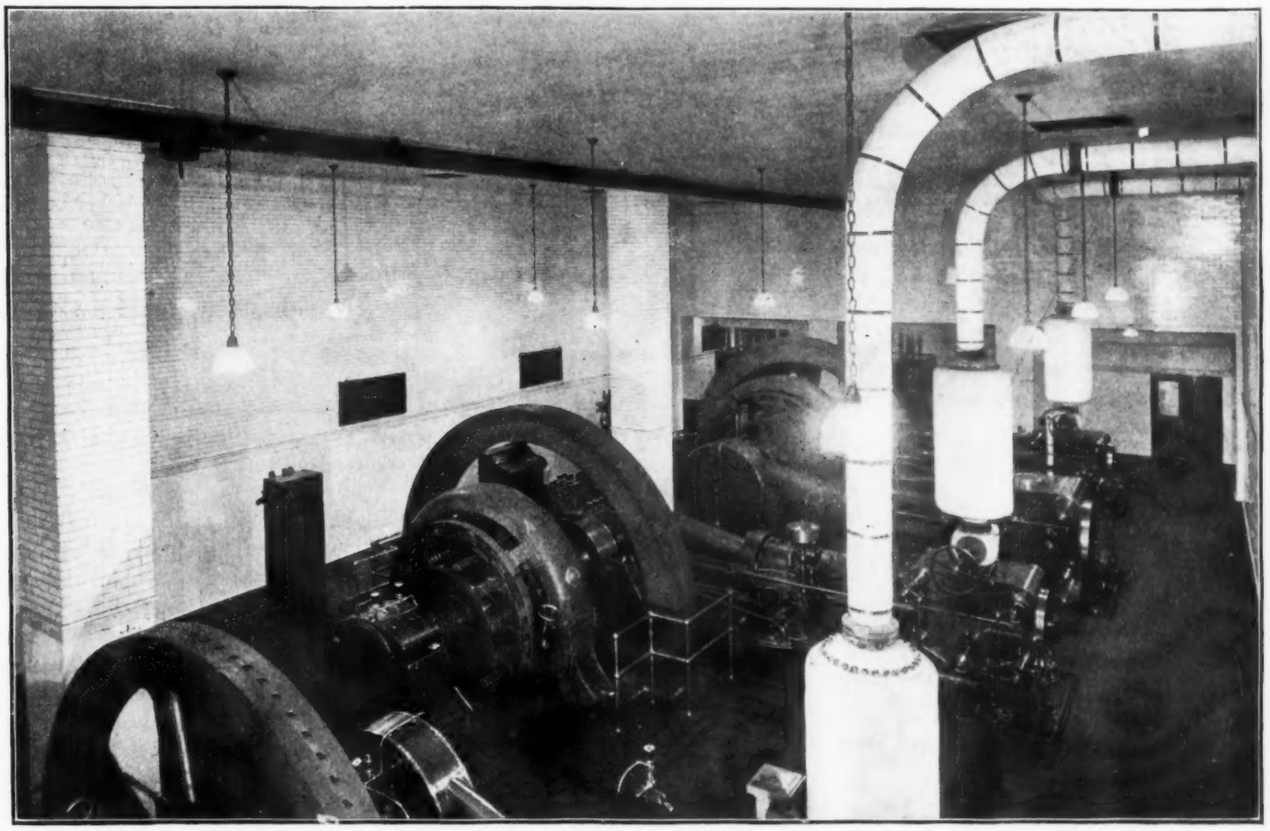
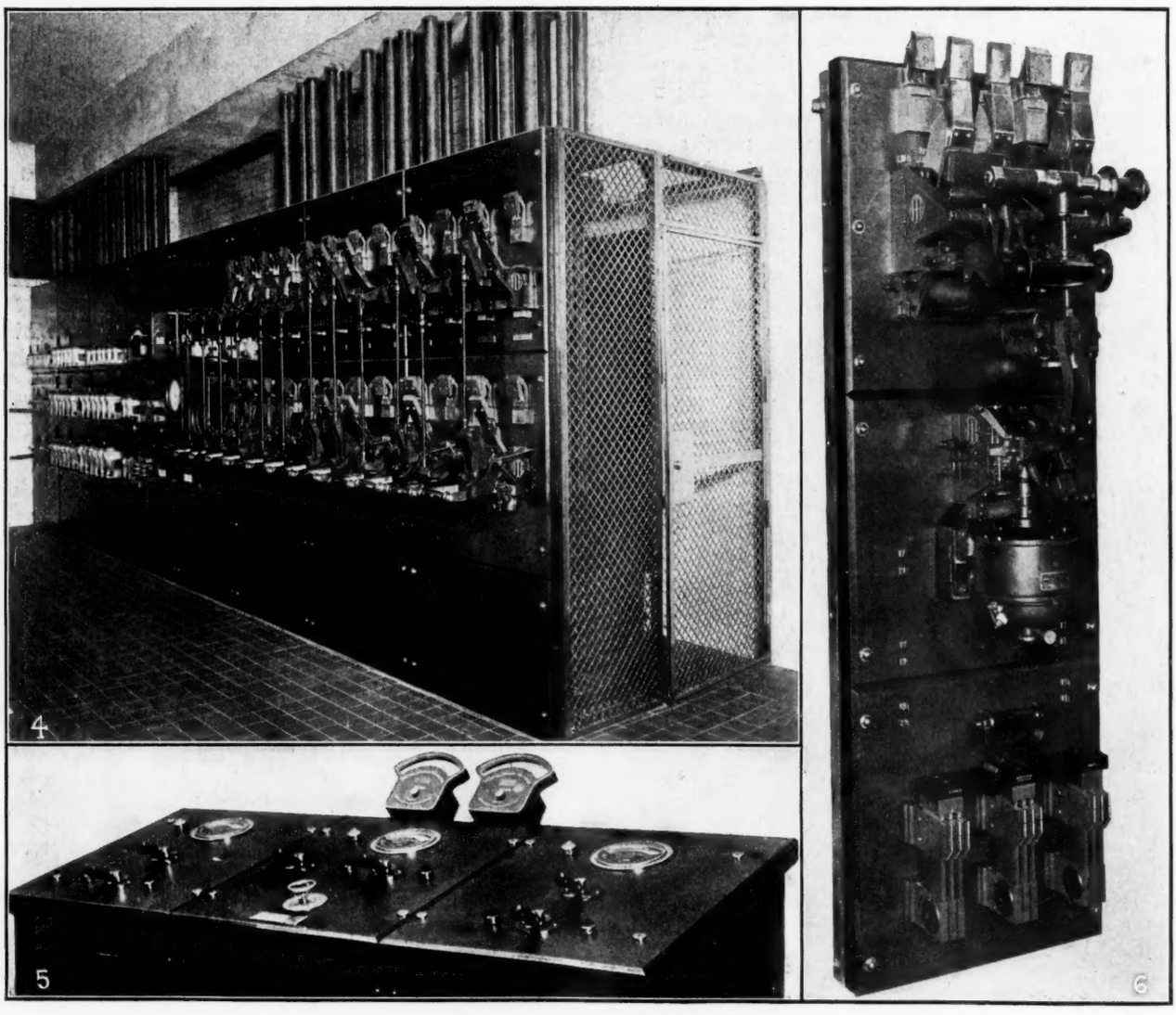


FIG. 3. VIEW IN THE ENGINE ROOM OF THE CONWAY BUILDING POWER PLANT

tion mounted on the guide bar and operated from the crosshead. Ring oil bearings are supplied by a gravity system, and oil cups have been provided also as an additional precaution. From the barrels in which it is received the oil is emptied into a filter and pumped to a 200-gal. storage tank at the top of the boiler room. Here it is maintained at a temperature of about 110 deg. and flows readily to the engine bearings, then back to the filter. The oil pumps are operated by compressed air at 35 lb. pressure. Force-feed oilers lubricate the cylinders. There is one feed to either side of the steam pipe and one on the piston rod. The oil is stored in the basement and the lubricators filled as need be.

Instead of including the generator-control panels and the feeder panels in one board as is usual in a plant of this kind, the switchboard, or rather the feeder board, has been limited to distribution and the instruments, the generating units being controlled on both the steam and electrical ends from a bench board erected near the feeder board and overlooking generator panels erected opposite to each machine. This arrangement is made possible by using motor-operated circuit-breakers and rheostats. The power required to close a circuit-breaker of the size needed on a 600-kw. machine is excessive for hand operation. On this account it was decided to install a motor-operated circuit-breaker, and to be consistent, circuit-breakers of the same type were provided for the other two machines. This arrangement looks somewhat complicated, but when it is considered that one man has control of the electrical conditions and also of the three engines without moving from one position, it will be seen that the advantage thus gained is worth the additional expense that is involved.



FIGS. 4 TO 6. DETAILS OF THE SWITCHBOARD IN THE CONWAY BUILDING
Fig. 4—Feeder board. Fig. 5—Bench control board. Fig. 6—Generator panel board

In laying out the feeder board single busses were provided. It had been decided to draw the current for light and power from the same source and not require the operation of two machines when the load did not exceed the capacity of one. During the elevator peak loads, morning, noon and night, severe conditions are imposed on the generators, so that in the specifications rigid requirements were placed on the closeness of regulation. The specifications called for a regulation within 3 per cent., but in the acceptance tests the maximum variation in voltage between the straight line connecting the half-load and the 1½-load points and the descending regulation curve did not exceed 2 per cent. Such an

excellent showing is probably due to the cast-iron frames and the liberal air gaps of the generators. Results obtained since in operation have been very satisfactory.

The eight-panel feeder board, shown in Fig. 4, is made up of 2-in. oil-finished Monson slate panels. Starting at the left, the first three are feeder panels of conventional design. The fourth contains the equipment for the two balancers, and the next is a meter panel containing four watt-hour meters for measuring tenant and public lighting, elevator and miscellaneous power. There are also a recording voltmeter and a recording ammeter, both of the continuous-record type. The voltmeter is standard, but the recording ammeter has a half-second vibrator, so that the pen record is made in dots and the friction of continuous contact eliminated. The three at the right are feeder panels equipped with two-pole 220-volt circuit-breakers with one pole arranged above the other. This simplifies the copper work back of the board. In addition to the inverse time-limit element these circuit-breakers have the nonclosable-on-overload feature.

Arrangement of the Feeder Board

At the ceiling above the feeder board a cable pull-box has been provided. This has three rows of transverse pipe covered with heavy fiber sleeves for the cables to rest on, while the bottom of the box is used as a fourth support. The cables come down in conduit through the deck plating on top of the feeder board to lugs joining them with the copperwork. On the lighting panels the poles of all switches, even of different sizes, are spaced uniformly for the sake of appearance at the front of the board and in order that the cables for the three rows of switches may be brought down one behind the other.

The feeder cables terminate in lugs arranged stepwise at the rear of the board, the lugs being of a pattern which offsets the center line of the cable from the center line of the copper bars. The cables themselves do not extend more than one foot below the top of the board. The lugs are attached to the bars by machine screws so placed that any lug may be tightened or removed without disturbing any others. Another unusual feature is the passing of a switch stud through a vertical copper bar rather than bending the latter to pass around it. Plenty of copper has been provided in the bars to allow for this construction, and a fiber sleeve slipped over the stud separates the two. This arrangement adds to the appearance back of the board.

It will be noticed that no lamp brackets have been provided on any of the panels. Illumination of the board is effected by a trough reflector on the ceiling, lighting the entire eight panels and the immediate surroundings.

Fig. 5 shows the bench board, from which both the generators and the engine may be controlled. At the top there are two voltmeters, one tied solid onto the main feeder-board busbars and the other controlled from a seven-point voltmeter switch. This instrument may measure the voltage of each generator, the voltage between neutral and either outside leg, and the voltage between the positive or negative and ground. Next in order come three ammeters, one for each generator, with bull's-eyes alongside to indicate at a glance which machine is in operation. Then come the rheostat-control switches, one for each machine, and one control switch for each of the generator circuit-breakers. The latter are provided with two bull's-eyes each—one red to indicate that the breaker is closed and the other green to indicate that it is open.

As previously stated, the circuit-breakers are motor-operated and, with the main generator switches, are on panels opposite each unit. For structural reasons it was impossible to excavate for a trench on the panel-board side of the machines, so that the cables between the panel boards and the main feeder board are all run in conduit. They come out in a trench back of the board and are carried up to lugs in the same way as the feeder circuits above. Fig. 6 is the generator panel, and Fig. 7 a section and plan of the lighting feeder panel.

In closing the circuit-breaker the control switch on the bench board is swung to the closed position. This starts the motor through a resistance and also energizes a solenoid, the plunger of which forces a worm gear on the

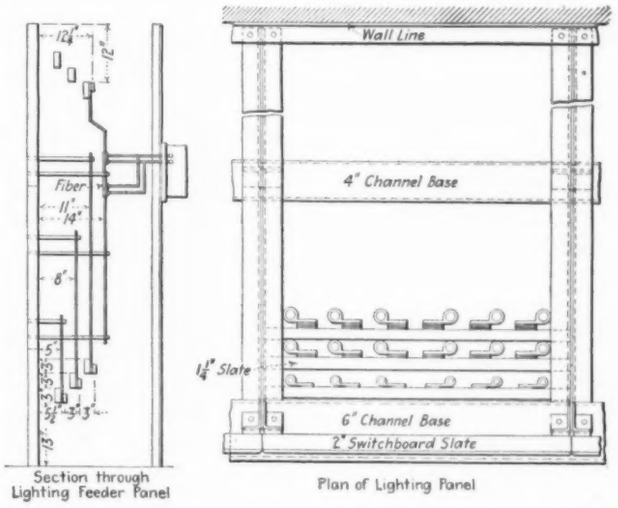


FIG. 7. CONSTRUCTION AT BACK OF LIGHTING PANEL

vertical shaft of the motor in mesh with a gear sector attached by a link to the circuit-breaker handle. The same movement of the solenoid plunger closes a localizing switch, which connects the motor directly with the control circuit and renders its further movement independent of the control switch. Thus when the closing is once started it must be concluded. At the completion of the closing movement a stop on the gear sector comes into engagement with a bell-crank lever, causing it to open the timing switch, thus disconnecting the motor and the solenoid coil and allowing the heavy plunger of the solenoid to pull the worm gear out of mesh with the gear sector. The motor is thus separated from the circuit-breaker, and the latter is free to act as soon as the gear is released. Should an abnormal current condition exist upon closing, the circuit-breaker is ready to instantly respond and open without restraint from the operating mechanism. The final movement of the breaker in opening is communciated to a bell-crank lever, which closes the timing switch and again places the motor circuit in condition to be closed from the bench board. The same methods are employed in controlling the positions of the field rheostats.

[The second installment of this article will contain descriptions of the boiler room, the instruments in the plant, the record system and a table listing the equipment.—Editor.]

Visits of Inspector Brown--XIV

By J. E. Terman

SYNOPSIS—Brown is called to account regarding a report requiring a new boiler setting, because no attention had been given to the danger of producing excessive strain on the pipe connection. The Chief tells Brown a few things that every engineer should know.

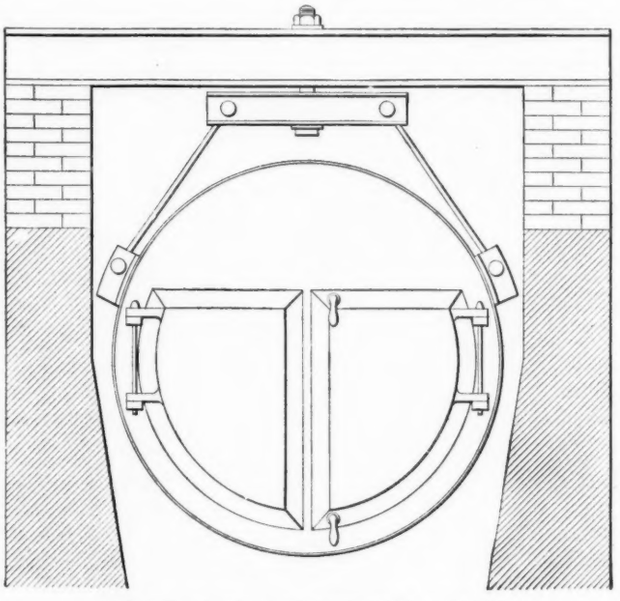
"Say, Brown, come into my office," said the Chief, as he passed the former's desk when coming from lunch. When Brown reached the Chief's office he noticed lying on the desk a report he had written out that morning on some horizontal-tubular boilers at a street-railway plant in the city. When Brown was seated the Chief said: "Now, Brown, you have made a rather serious mistake in writing this report, but you are no doubt in blissful ignorance of the error, and I never like to censure a man who makes a mistake because he doesn't know better, unless he has had ample opportunity to learn. You have made a clear report on the conditions found at this plant, and you have made requests for some necessary repairs, and this report shows that you must have made a careful inspection of the boilers; but you have given the engineer credit for knowing more about the danger from improperly supported boilers than you seem to be aware of yourself.

"I note in this report," continued the Chief, "that you have specified that the No. 3 boiler must have the front end of the side setting wall rebuilt and that the work must be done within two weeks' time. The time limit set indicates that the condition of the wall is serious. In fact, you have called the attention of the owners to the fact that the condition of this portion of the setting wall is liable to cause a serious accident to the boiler unless promptly repaired, but you have not cautioned them about the need of seeing whether the boiler has not already settled enough to produce an excessive strain on the pipe connections to it.

"With a wall in the condition that this report indicates, there is danger that the boiler has already settled from its original position and that the pipe connections to it now have a strain on them from this cause. The most natural thing for a brick mason to do when he comes to repair that wall will be to block up the boiler in the position it then occupies and rebuild the wall, letting the boiler down on the new brickwork just as soon as he gets it completed. Every move made will tend to lower the final position of that boiler. The blocking used may not be put in tight enough to prevent the boiler settling a little when the portion of the old wall is removed. It will be almost an impossibility for the new wall to be built up so tight against the boiler lugs, even by using the shims that they will use to prevent settling when the blocking is removed; and besides, the brickwork will no doubt be green when the blocking is taken out and the wall itself will settle some.

"Now, the very best conditions that we can expect to exist after the job is completed, if the work is performed as I have suggested, is that the boiler will rest on two lugs at opposite corners instead of on all four, and we may expect that the main steam-pipe connection and other points where pipe connections to the boiler are made will be under heavy stress. I believe that in many of the mysterious boiler explosions, where a perfectly sound boiler blows up and everything points to the fact that the safety valve was operative and that no excessive pressure could have existed, the settling of the boiler due to the setting wall giving way or other similar cause would explain the accident if we only knew what had been going on.

"When a boiler is to be reset, always caution the owner to have the bolts in one of the flanged connections in the main steam connection and near the outlet from the boiler removed; to see, when the resetting of the boiler is finally completed and the walls have dried out enough so that no further excessive settling can take place, that



THREE-POINT SUPPORT FOR BOILER

the pipe connection can be replaced without requiring the use of a block and tackle to get them together; and to have the boiler a little higher than necessary rather than a little lower, because boilers rarely change from a lower position to a higher one, unless because of an explosion. The blowoff should also be disconnected, to make sure that there is no excessive strain on this pipe when the work of resetting is completed."

"Well," said Brown, "I never thought before of the many dangers that might result from the resetting of a boiler that was connected to pipe lines. In fact, I never understood why so many rivets were usually placed in the brackets on boilers, but now I can see that a bracket may be called upon at any time to support one-half of the weight of a boiler instead of one-fourth, as is usually figured where four brackets are used. It is a dangerous plan to support a boiler at more than two points on a side, for the main portion of the load would more than likely come on the center lugs, and if all the weight of the boiler is to be carried on two lugs they should be placed near the ends of the shell in order to receive the benefit of the stiffening effect of the heads to prevent undue distortion of and strain in the shell."

"Yes," said the Chief, "it is true that two lugs are often called upon to carry the weight of the boiler and they may be called upon to also help support the roof of the boiler house, for, as you will remember, we found the roof over Johnson's woodyard boiler supported by props placed on top of the boiler shell. In order to be sure just how much of the weight each lug of a boiler is supporting, it is necessary to use a three-point support about like this [see illustration]. This rig is applied to one end of the boiler, and the other end may be carried on lugs resting on the side walls of the setting, or preferably be hung from an overhead support in the usual way."

"Well, Chief," said Brown, "I feel guilty about my report on that plant, and if you will give it back I will go out there this afternoon and try and have them put on a three-point support on that boiler, although I am afraid the manager will not loosen up to that extent, and I will show the engineer how cautious he must be to see that the original position of that boiler is maintained after the repairs to the setting walls are completed.

"To change the subject I would like to know why it is that we are so careful to figure the stress on the longitudinal seams on a boiler while we do not take any account of the load placed on the shell because the weight of the boiler is carried on the lugs, and is added to the direct tensile stress in the shell produced by the steam pressure."

Relative Importance of Longitudinal Seam

"One legitimate reason," answered the Chief, "is that the longitudinal seam of a boiler is usually considerably weaker than the solid plate, and lugs are never attached to the boiler shell by any of the rivets used in the longitudinal seams, and therefore the strength of the shell at the point where the lugs are attached is a separate proposition. We cannot consider the connection between the lugs and the shell of the boiler as a longitudinal seam, because of the short length of plate involved. It is a mistake, however, not to consider the method of attaching the lugs most carefully, as a factor in the case when considering large boilers of the horizontal-tubular type, particularly with respect to their relative position with the longitudinal seams.

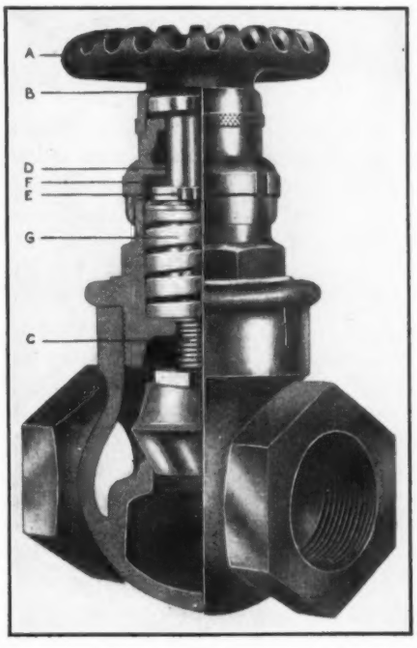
"The position of the lugs in relation to the longitudinal seams on a boiler has no doubt been a factor in causing many explosions that have resulted from lap cracks at such seams," continued the Chief. "Where large boilers of the horizontal-tubular type are to be supported on lugs, the design of these lugs is most important, and the part attached to the boiler shell should encompass a sufficient portion of the circumference so that the load will be properly distributed and not concentrated."

"How about hanging boilers from lugs attached to bumped heads?" asked Brown.

"That is bad practice," said the Chief, "unless the load supported is very light, for we frequently find such heads cracked in the turn of the flange, where there is no fitting of any kind attached to them. There is undoubtedly a breathing action on such heads when designed along the usual lines with a presumed safety factor of five, and any load that might be added to that produced by the steam pressure certainly would not tend to prevent such cracks in the flange."

Universal Nonpacking Valve

The high-pressure valve shown in the accompanying illustration is distinguished from the usual type of valve by two distinct features—the entire absence of packing and the use of a cast-iron spring. Valves of the type shown have been in use in a number of plants for some time and have proved satisfactory for high-pressure work. As may be seen from the illustration, the handle *A* is nonrising. It swivels on the shoulder *B* and is independent from the main valve stem. A square socket in the handle turns a crank, the lower end of which fits over a square head on the main threaded spindle *C*. As the valve opens and closes, this head moves up and down in the recess of the shank. Between the rigid shoulder *D* and the revolving shoulder *E* is a grooved ring of bearing metal *F*, which serves as a constant seat and prevents water or steam rising above it. The spring *G* holds the ring and the two shoulders tightly together. Contrary to usual practice, the spring is made of cast iron under the Knudsen patents. Such an application of cast iron is novel, but from all indications the spring is a decided success. As it has no temper, heat cannot change it. Tests of springs that have been in regular use for three years have shown no change in tension or resilience. In a testing machine the spring was tested to 10,000,000 deflections and showed no set. Upon calipering the spring before and after the test, the same dimensions were obtained. It has no loose end, top or bottom, and presses against upper and lower surfaces, which do not turn with the handle or stem.



UNIVERSAL NONPACKING VALVE

The valve, which may be used not only for high-pressure steam but also for water, gas, air and ammonia, is made by the Universal Valve Co., 910 S. Michigan Ave., Chicago. This company has the sole right to make the springs previously described. Besides supplying the valve complete, it will furnish nonpacking bonnets to fit any size and style of valve on the market.

Effect of Viscosity may be made clear by remembering that when a lubricant adheres, to a certain extent, to two surfaces having a different rate of motion, a shearing stress is set up at every point within the lubricant in splitting or separating the two parts from each other and the work so done is manifested in heat generated.

Surveys of the Available Water Power throughout British Columbia show that 3,000,000 hp. can be developed from the streams of this province, and that only about 8 per cent., or approximately 240,000 hp., has been made use of up to the present.—"Mechanical World," Manchester

Nonreturn Stop Valves--I

SYNOPSIS—Various types of check and nonreturn stop valves have been designed to prevent steam from flowing from a steam header into a boiler or from a boiler into a steam header, in case of an accident to either, due to a rupture. Valves of various design are described and illustrated in this article.

Serious accidents, often fatal, result so frequently from bursting steam pipes and fittings and rupturing boiler tubes that every power plant should guard against such accidents by placing some type of nonreturn valve in the steam line and between the boilers and the main steam header. Such appliances will also reduce the damage resulting from the rupture of pipe lines and of boiler tubes.

Power has published within the last few years many accounts of power-plant accidents where lack of protective valves has resulted in needless loss of life. True a nonreturn valve will not prevent the contents of the boiler escaping into the boiler room, when a boiler tube bursts, but the steam contained in all the other boilers connected to the steam header will be prevented from blowing out through the crippled boiler. As a result the one boiler is automatically cut out of connection with the main header and the plant operation can go on without interruption.

The safety valve is a recognized necessity as a means to prevent excessive steam pressure in a boiler. A nonreturn valve is practically as essential for preventing the escape of steam from a main header into the boiler room or from the steam main into an empty boiler in which men may be working.

The importance of installing nonreturn valves in the piping systems of power plants is so well recognized by mechanical and operating engineers that scarcely any new power plant that can be classed as modern and uptodate is built without such valves.

This article describes briefly the construction and operation of different types of nonreturn valves. The arrangement and treatment are not intended to indicate that one is considered as having more merit than another.

Acton Nonreturn Valve

Among the several designs of nonreturn valves is that shown in Fig. 1. It is different from many others in that it can be used as a stop valve for both closing and opening by hand. It is made with the dashpot *A* above the valve disk *B*. The top of the dashpot piston has a screw plug *D* through which the valve stem extends, the bottom end of which is made with a collar. If it is desired to open the valve, the stem is screwed up and the collar *C* engaging with the plug *D* carries the disk *B* with it. Screwing down the valve stem brings its end against the valve disk and forces it against its seat.

When the valve stem is in mid-position, that is with the groove *E* opposite the pointer *F*, the dashpot and valve disk are free to operate automatically and close the valve against steam flowing from a header to the boiler in case of a tube rupture or decreasing pressure from any other cause. The dashpot piston has two packing rings and is in one piece with the valve disk. This gives a long guiding surface, so that with the addition of the lugs below the disk, the valves will seat squarely.

Belfield Nonreturn Valve

The valve, Fig. 2, is made in globe and angle types, the interior construction of both being the same. In this valve the dashpot *A* is a part of and below the valve-seat casting *B*. The upper part of the dashpot chamber has large openings *C* for the passage of steam through the valve. The valve disk is made with a cylindrical chamber in which the valve stem *D* has a sliding fit and serves to guide the disk in its movement.

When using the handwheel in closing the valve, the end of the stem *D* comes against the bottom of the chamber *E* and forces the disk to its seat against the boiler pressure which is below the disk, and flows in the direction of the arrows. Should a rupture occur in a boiler tube, the steam pressure in the main and above the valve

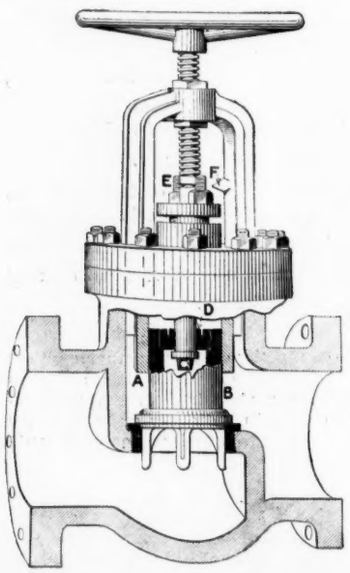


FIG. 1. ACTON VALVE

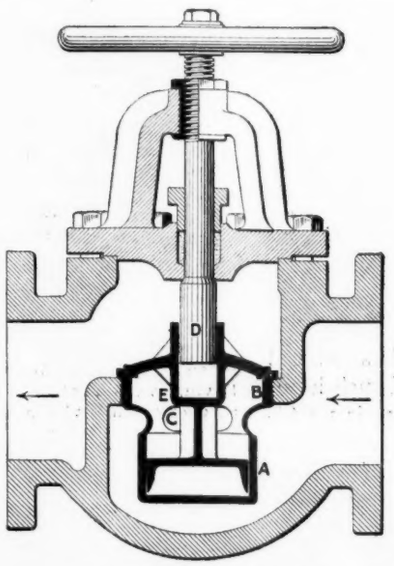


FIG. 2. BELFIELD VALVE

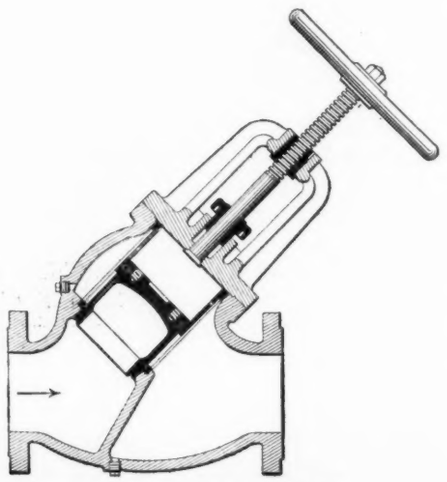


FIG. 3. CRANE VALVE

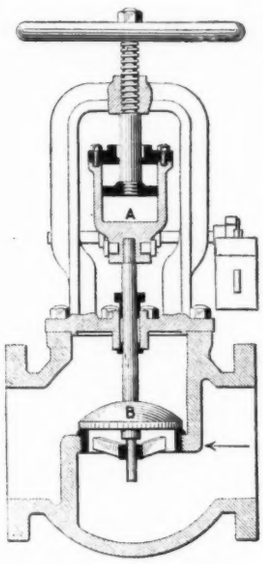


FIG. 4. DAVIS VALVE

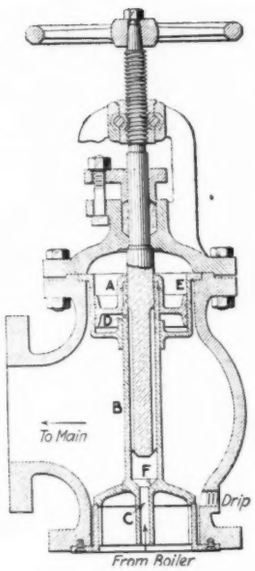


FIG. 5. EYNON-EVANS VALVE

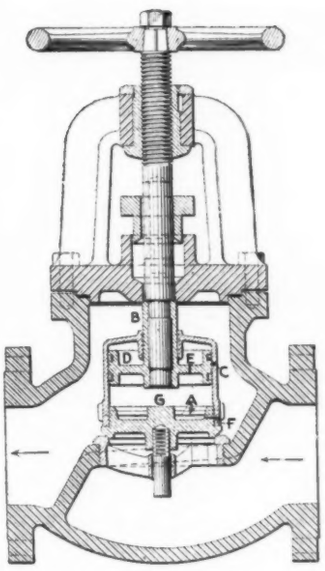


FIG. 6. EDWARDS VALVE

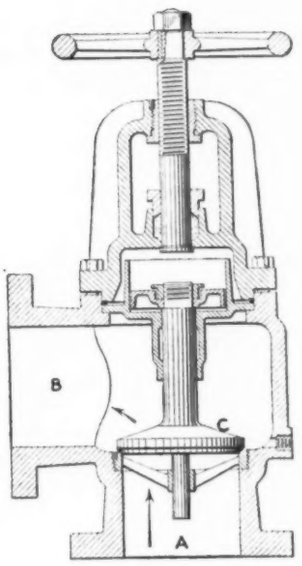


FIG. 7. FOSTER VALVE

disk forces the latter closed, thus shutting off the flow of steam to the damaged boiler and into the boiler room.

Crane Automatic Y-Stop Check Valve

This valve is shown in Fig. 3. The seat can be taken out after removing the valve cover, likewise the disk and piston, which are in one piece. The valve disk has a full-length bearing in a liner in which are ports of suitable area for the passage of steam. The arrow shows the direction of steam travel, the boiler pressure coming underneath the disk. As in most other valves of this type, the valve stem and handwheel permit closing the valve by hand, but it cannot be opened until actuated by the steam pressure on the under side of the disk.

Davis Automatic Stop and Check Valve

A feature of the valve shown in Fig. 4 is the oil dashpot *A* on the upper end of the valve stem, where it is not affected by the heat of the steam. To make the effective area of both sides of the disk equal, a counterweight (details not shown) is provided to balance the pressure acting on an area equal to that of the stem. This counterweight lever moves in unison with the disk and can be used in testing the action of the valve as well as serving as an indicator.

A handwheel is provided, by which the valve may be permanently closed, but it does not interfere with the automatic action of the valve when it is screwed out. The boiler pressure comes below the disk *B*, and if the pressure is reduced on that side, the valve closes, shutting off communication from the steam line or main header. The dashpot prevents the valve from closing too suddenly. If a boiler is not kept up to the average header pressure, the valve will close and prevent the other boilers from keeping up its steam pressure; therefore the steam gage will show that that particular boiler is not producing its share of steam.

Edwards Nonreturn Valve

Another design of valve is shown in Fig. 6. It is of the dashpot type with the disk screwed to the inside of the dashpot and held in place by the pin *A*. On the lower end of the stem is a sleeve *B*, the upper end of which forms a seat in the bonnet to allow of packing the stem while under pressure. The inside surface of the dashpot rides on the rings *C* of the piston *D*, and the top of the dashpot rides on the neck of the piston.

Into the lower end of the valve disk is screwed a guide pin which runs through a guide in the seat. Through the piston at *E* and also through the side of the dashpot, near the bottom at *F*, is a small vent hole. These holes serve not only to maintain equal pressure inside and outside of the dashpot, but also, and chiefly, to assist in the cushioning effect that is produced when the valve opens and closes. This is because the steam entrained on either side of the piston *D* must pass through these small holes and so compel a gradual movement of the disk in opening and closing, owing to the compression acting on the piston.

When the valve is to be closed as a stop valve the piston *D* is forced down by the valve stem, as it is screwed against the projection *G* and the continued inward move-

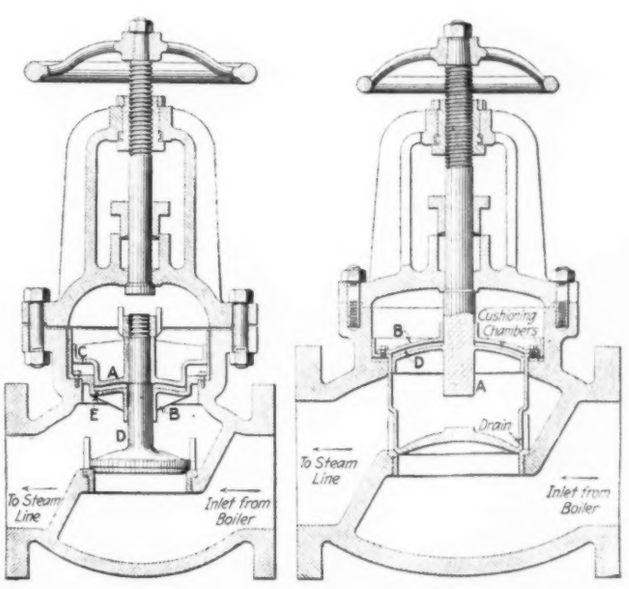


FIG. 8. TWO DESIGNS OF GOLDEN-ANDERSON DOUBLE-CUSHION NONRETURN VALVES

ment of the valve stem will force the disk to its seat. To permit the valve to act automatically again, it is necessary to screw the valve stem out to its full travel.

This type of valve is also designed for vertical pipe lines. For restricted places the bonnet and stem are not used, the valve acting solely as a nonreturn check valve.

Foster Automatic Nonreturn Stop Valve

Another nonreturn valve, Fig. 7, has an inside dashpot, the piston of which is secured to the stem of the valve disk. A tail piece projecting from the bottom of the disk brings it to a true seat when the valve closes.

The inlet *A* is piped to the boiler connection, the outlet *B* to the header. When the pressure below the disk *C* is one pound or more greater than the pressure on the discharge side, the disk lifts and is held open by the flow of steam. If the pressure at *A* falls below that at *B*, the back flow of steam acting on the upper side of the disk *C*, together with its weight, forces the valve to its seat and the disk will remain in that position until the pressure on both sides of the disk equalizes. The dashpot is, as in other similarly designed valves, to prevent shock and chattering of the valve disk.

Eynon-Evans Emergency Valve

The Eynon-Evans emergency valve, Fig. 5, has features that are different from other valves for similar purposes. The valve stem is enlarged for part of its length to form a bearing for the piston *E*. The valve stem *B* is screwed into the piston *E*, which has an outside bearing against the walls of the dashpot.

The valve disk has a hollow center *C* through which steam at boiler pressure passes to the under side of the piston *E*, through the port *D*. The upper side of the piston communicates with the header side of the valve through the port *A*.

If the pressure below the valve disk drops more than 2 lb., the pressure on the header side of the pipe will seat the valve disk. The valve can be closed by hand; the extension of the valve stem comes in contact with the seat *F* as the stem is screwed in, and the disk is seated like an ordinary stop valve.

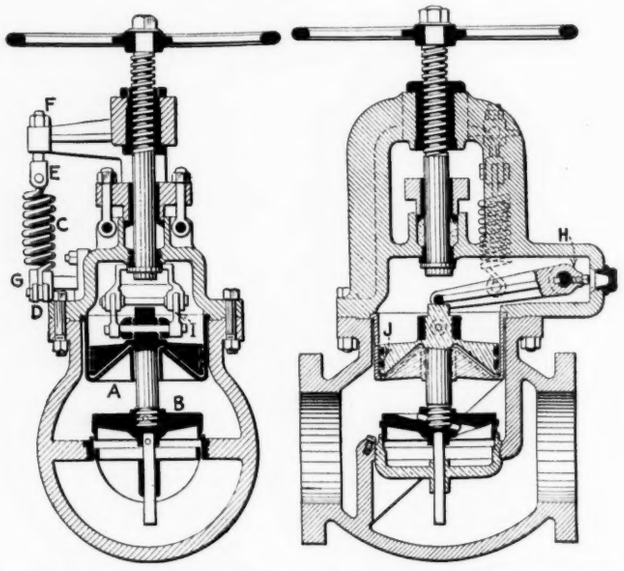


FIG. 9. DETAILS OF DESIGN OF THE LUNKENHEIMER NONRETURN STOP VALVE

A feature of this valve is the manner of securing the valve seat and the dashpot in place. The valve seat fits in a recess in the bottom of the flange. It is held by screws and forms a seat for the pipe flange, which is bolted to the valve. The dashpot rests in a recess at the top of the valve and is held tightly in place by the valve bonnet.

Golden-Anderson Double-Cushion Valves

Two valves are shown in Fig. 8. The first has a double dashpot *A* to cushion the main valve when opening and closing the piston. The space above and between the inner and outer dashpots *A* and *B* is filled with live steam through the ports *C* and *E*, when the valve disk *D* rises from its seat, owing to the boiler pressure. This steam in the dashpots cushions the valve in closing. As the full boiler pressure is always above the dashpot *A*, the valve will close when the pressure decreases on the under side of the valve disk.

A branch pipe connecting with the area between the dashpots (not shown) leads to a point convenient for operating a small bleeder valve from the floor. When the bleeder valve is opened, the pressure between the dashpots is relieved, and as the area of the dashpot piston is greater than that of the main valve disk, the latter is forced to its seat and the steam pressure from the boiler is shut off. This bleeder arrangement gives the operator the opportunity of determining whether the valve is operating, without the trouble of closing the valve by the handwheel, which permits of operating the valve as a main stop valve.

The other valve, Fig. 8, is cushioned in both directions and is made positive in operation because of the large area that is effective for the steam pressure, which acts to close the valve in case of its automatic operation. This cushioning is carried out by a double dashpot, which occupies the full area of the upper portion of the body and is to prevent hammering or pounding.

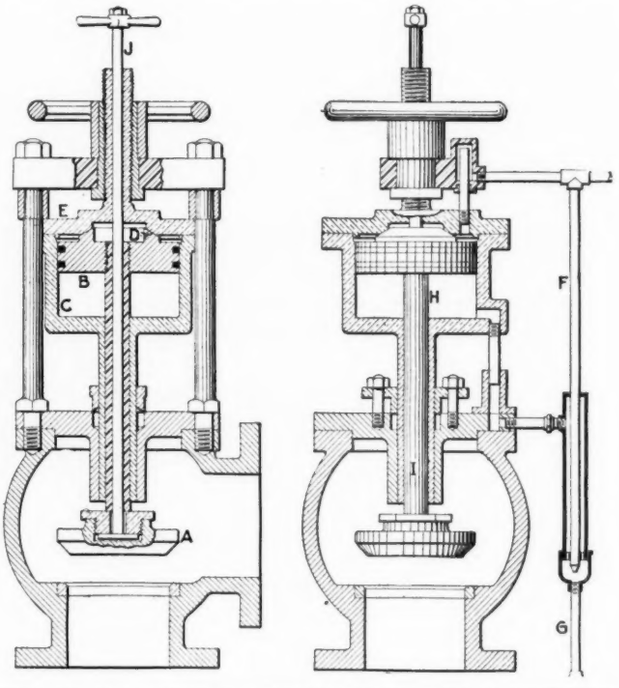


FIG. 10. McLAUGHLIN AUTOMATIC SAFETY NONRETURN STOP VALVE

When the steam pressure raises the hollow valve, there exists a space D between the top of the hollow valve and the disk B. This space is filled with steam which leaks past the disk. The area above the hollow valve is also filled with steam, so that the valve is cushioned both in opening and in closing. To test the valve in service steam is permitted to exhaust from the cushioning chambers by opening a hand-valve that may be located where convenient. The nonreturn valve will then automatically close, but by closing the exhaust the nonreturn valve moves back to the open position ready for automatic action. By screwing in the valve disk by turning the handwheel, the valve can be used as a stop valve, the projection A of the stem coming in contact with the one on the upper side of the valve disk, thus forcing it to its seat. Screwing out the valve stem permits the disk to open automatically.

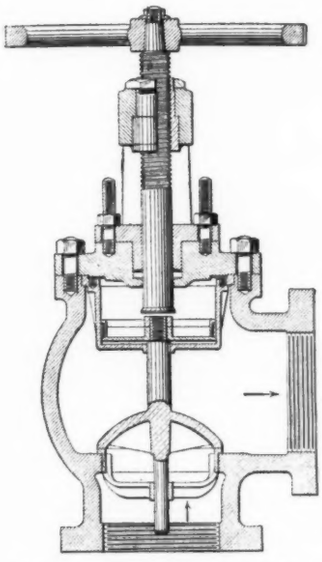


FIG. 11. JENKINS EQUALIZING STOP AND CHECK VALVE

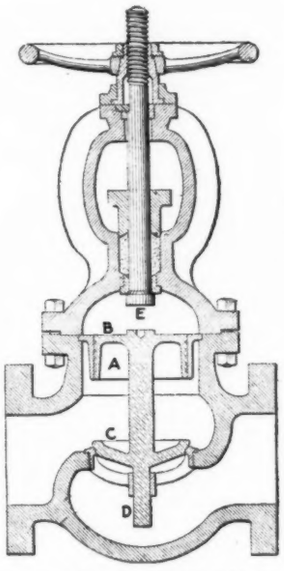


FIG. 12. NELSON NONRETURN STOP AND CHECK VALVE

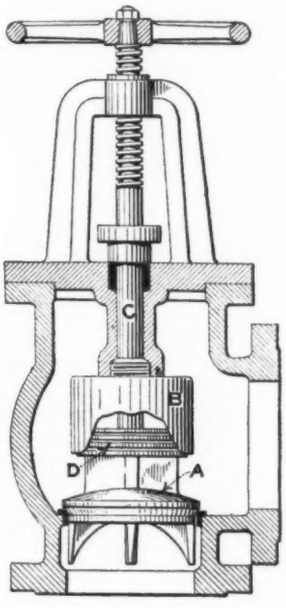


FIG. 13. PRATT & CADY STOP AND CHECK VALVE

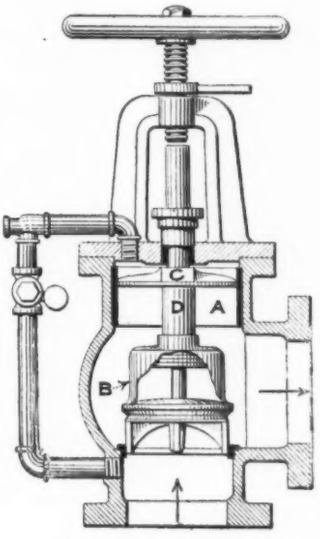


FIG. 14. PRATT & CADY TRIPLE-DUTY EMERGENCY VALVE

Jenkins Bros. Automatic Equalizing Valve

The valve shown in Fig. 11 also equalizes the pressure between different boilers in a battery, preventing one from working at a lower pressure than another.

The valve action is cushioned by an inside bronze dashpot that prevents the danger of sticking through corrosion. The internal parts of the valve are easily removable after taking off the bonnet. The valve stem can be repacked under pressure while the valve is wide open; the seat ring is removable. The valve can be operated as a hand stop valve by screwing in the valve stem. The disk has a guide at the bottom. Its operation is similar to that of the valves described in the foregoing. The steam from the boiler is below the disk.

Lunkenheimer Nonreturn Stop Valve

The nonreturn valve shown in Fig. 9 can be operated as a stop valve by screwing in the valve stem. It has an internal dashpot A to cushion the closing of the valve disk B. In addition an outside spring C and lever D cause a slight counterbalancing effect to hold the valve open. This is to counteract the influence of steam pulsations, which tend to move the valve disk up and down with every slight fluctuation of pressure such as is usually caused by a reciprocating engine. This constant motion would in time cause considerable wear. If there are no pulsations, the use of the lever and spring mechanism is not required and the spring can be adjusted without tension, as the dashpot cushions the disk movement.

The motion of the stud E is an evidence of the valve movement, which can be stopped by placing the spring C under tension by adjusting the nut F, which tends to lift the disk from its seat as it puts the spring under tension, causing it to pull upon the lever D. This lever is keyed to the shaft G, which enters the valve through a stuffing-box. Attached to the shaft is a forked arm H, to which are pivoted the links I, which in turn are loosely connected to the piston J.

When the spring is under tension, the disk cannot close until the steam pressure above the disk exceeds that under it, and this difference in pressure, which is governed by the tension on the spring, is not more than 5 lb. With the valve properly set to overcome the tendency of pulsating, the disk remains practically in equilibrium until there is a reduction in pressure on the inlet side, when it will close.

McLaughlin Safety Stop Valve

A type of stop valve designed to cut off the flow of steam automatically and manually from any point and at any distance or from any number of points is illustrated in Fig. 10.

The valve disk A is closed by a piston B, which works in a cylinder C. The piston is larger in diameter than the valve disk to give a greater area to overcome the pressure acting on the under side of the disk. The piston B has a seating surface D at the top, which, when the valve is open, comes against a seat E on the top of the cylinder. This makes the valve differential, so that when it is in its normal position the area exposed to the steam pressure on the back of the piston B is less than that exposed next to the valve disk. This makes

the valve remain open until the disk is closed by hand or by the irregularity of the steam pressure, both sides of the piston being under pressure, as shown by the piping *F*.

The valve can be operated manually from any number of safety boxes connected to the pipe *G*. Each of these boxes has a short section of common water-gage glass, which can be readily broken when necessary. One end connects with the release pipe *G*, the other end is plugged. The effect of breaking the glass tubing is to release the pressure in the under side of the piston through the pipe *G*, and the steam pressure exerted against the top end of the piston forces the valve *A* closed.

The bottom end of the piston has a hollow stem *H* that slides in a sleeve *I*. A loosely fitting stem *J* extends from the valve disk to a threaded sleeve, to which it is secured. As the handwheel is turned, it screws the stem *J* downward until the disk reaches its seat. Before steam can open the valve disk, the stem must be raised by turning the handwheel in the proper direction.

Nelson Nonreturn Stop and Check Valve

In Fig. 12 is another valve which has an inside dashpot *A*, above the valve disk *C*. This is aligned by the guide pin *D* that passes through the seat ring. The disk and piston are cast in one piece, which avoids any chance of their separating because of pulsation.

The dashpot is the same width as the face of the piston *B*, so that the piston travel is the full length of the dashpot. This prevents grooves forming in the walls of the cylinder. The upper central part of the piston *B* has a projection with which the end of the valve stem *E* contacts when the valve is closed by hand, which it is desirable to do while a man is working in the boiler. The valve stem can be packed while the valve is in an open position.

Pratt & Cady Stop and Check Valve

The stop and check valve, shown in Fig. 13, like other valves of this type, cannot be opened while pressure is on the upper side of the disk *A*. The dashpot *B* is attached to the bonnet, and the valve can be closed with the handwheel by screwing down the stem *C* until the cylinder *B* touches the piston *D*, which, being a part of the disk, forces it to its seat.

The dashpot piston has grooves, which, because of the condensation that accumulates in them, take up the play between the dashpot and the piston. The valve is furnished with a bypass, if desired, for draining steam from branch pipe lines or for equalizing the pressure on the boiler that is ready to be placed in service. The valve is always placed in the pipe line with the stem vertical, the boiler pressure entering under the disk.

Pratt & Cady Triple-Duty Emergency Valve

The valve shown in Fig. 14 is usually installed on a boiler or between a boiler and a main header. It is used like an ordinary stop valve, but has a disk that is kept in equilibrium and automatically closes when the boiler pressure is reduced.

In this valve the cylinder *A* is fitted to the body of the valve. The piston *C* is secured to the valve stem *D*. A pipe connection is made from the space below the valve disk to the chamber above the piston *C*. Any reduction of pressure at the outlet end of the valve results in the higher pressure being above the piston, which has a larger area than the valve disk, forcing it downward, thereby bringing the disk to its seat.

The piston will remain suspended in the top part of the chamber, and the disk will be kept from its seat so long as the pressures above the piston, in the inlet and in the outlet are equal. The boiler pressure enters below the valve disk. This valve is also made with double pistons and cylinders. It will remain open until the outlet pressure has dropped 10 per cent. below the initial pressure, the top piston being 10 per cent. smaller in area than the lower one. Regulating the action of the valve for a 10-per cent. drop in pressure is sometimes desirable where abnormal load tends to reduce the pressure in the header. The valve can be used as an ordinary stop valve.

Nash Hydro-Turbine Air Pump

A turbo-vacuum and low-pressure boiler-feed pump, designed primarily for vacuum steam heating for use in connection with direct-return systems is illustrated herewith.

The pump unit consists of an air and a water pump combined in one casing. Referring to Fig. 2 the air pump is shown at *A*, and the centrifugal water pump at *B*, the rotor of each being mounted on the same shaft. The water inlet is at *C* and the outlet at *D*, Fig. 3. The air inlet is at *E* and the outlet at *F*, Fig. 2.

The water is separated from the air before reaching the pump, where each is handled separately. Water only is delivered against the boiler pressure, and the relatively large quantity of air is delivered against atmospheric pressure.

The water pump, Fig. 1, is made with an inclosed bronze impeller mounted on a shaft that runs in ball bearings. A close clearance is maintained between the

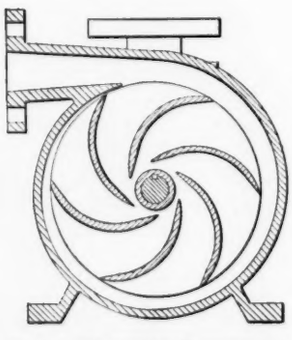


FIG. 1. SECTION THROUGH WATER PUMP

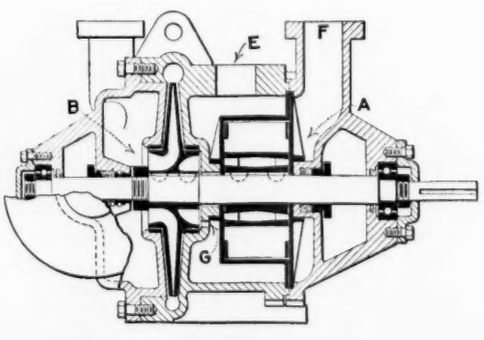


FIG. 2. COMBINED WATER AND AIR PUMP

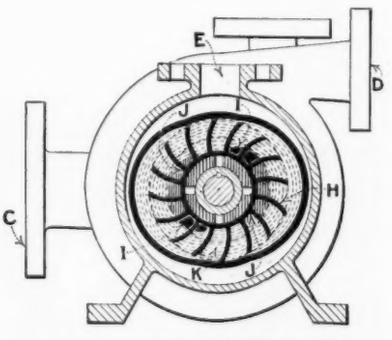


FIG 3. SECTION THROUGH AIR PUMP

packing rings and the impeller, thus limiting the leakage. The packing rings are easily renewed. The leakage from the right side of the impeller passes through the hole *G* and is used to supply the air pump with water.

In Fig. 3 is shown a cross-section of the air pump. It consists of a rotor *H* which runs in an elliptical casing. The rotor carries around with it water, which follows the casing because of centrifugal force. As the water alternately recedes from and surges back into the rotor, it acts as a piston, drawing in air and expelling it through the ports *I* and *J* in the side of the casing. The rotor is full of water at *K*, and as it revolves, the water is driven out into the casing by centrifugal force, drawing air in through the inlet ports *I*. As soon as the spaces between the blades of the rotor containing air have passed the inlet ports *I*, the water, forced in by the contracted shape of the casing, begins to reënter the rotor, thus gradually compressing the air.

When the terminal pressure is reached, the spaces between the rotor blades begin to register with the outlet ports *J*. The water continues to enter the rotor and drives the air out through the outlet ports until the spaces between the rotor blades are full of water at *K* and ready to repeat the cycle. The bulk of the water stays in the pump at the level of the outlet ports, but a small amount is carried over with the air as it is delivered. To make up this loss water is supplied to the air pump from the return of the heating system coming in through the port *G*, Fig. 2. The air is freed of this water in a separator and is returned to the heating system automatically.

This pump is capable of handling a large volume of air efficiently and will give a maximum vacuum of 20 in.

The outfit is manufactured by the Nash Engineering Co., South Norwalk, Conn.

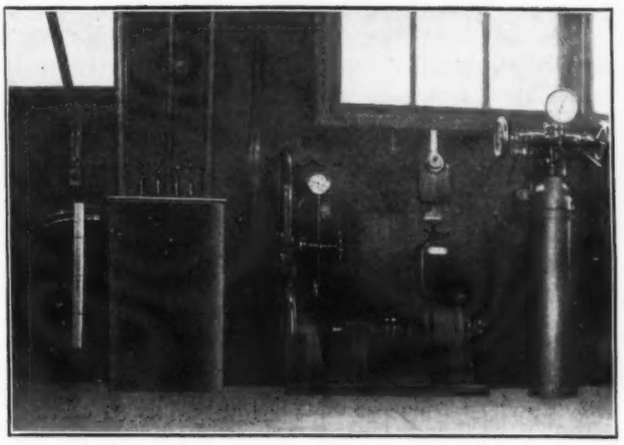


FIG. 2. DISCHARGE TANK AND PUMP IN ENGINE ROOM

Cooling System for Diesel-Engine Circulating Water

By A. V. Youens

Before installing the cooling system approximately 30 gal. of water per minute was being wasted in the cooling of the four cylinders of our 300-hp. horizontal Koerting Diesel engine. As this engine operates continuously, the daily waste amounted to 43,200 gal., which at 12c. per 1,000 gal. cost $5.18. Therefore the advisability of cooling the jacket water for continuous circulation was apparent.

Fig. 1 shows the general construction of the cooling tower, which is placed on the highest part of power-house roof, where there is a free sweep for the wind. The catch basin, or pan, is of No. 18 galvanized sheet metal, the lapped joints being riveted and soldered. The pan measures 12x32 ft., with the edges turned up 8 in., and rests on flooring slightly sloping toward one corner. The inverted V-shaped framework is of steel T-bars, each 26 ft. long and bent while hot around a 7½-in. radius at the middle with the stem of the T out. The bottom ends, or legs, of the inverted V spread about ten feet. The bars are spaced and held together at the top by circular crown-sheets of No. 10 galvanized iron, riveted to the flanges. The legs are correspondingly spaced at the bottom, being bolted to a rectangular angle-iron frame lying on the bottom of the catch pan. Tie rods prevent spreading of this rectangular frame. This construction makes a stiff framework, the whole being anchored to the walls of the power house by four guy lines, as shown. The spacing of the inverted V-sections is such as to allow a 36-in. width of No. 6 mesh galvanized wire cloth to be laid over the crown-sheet and down either side, the edges of the cloth being fastened securely to the flange of T-bars by brass bolts and washers.

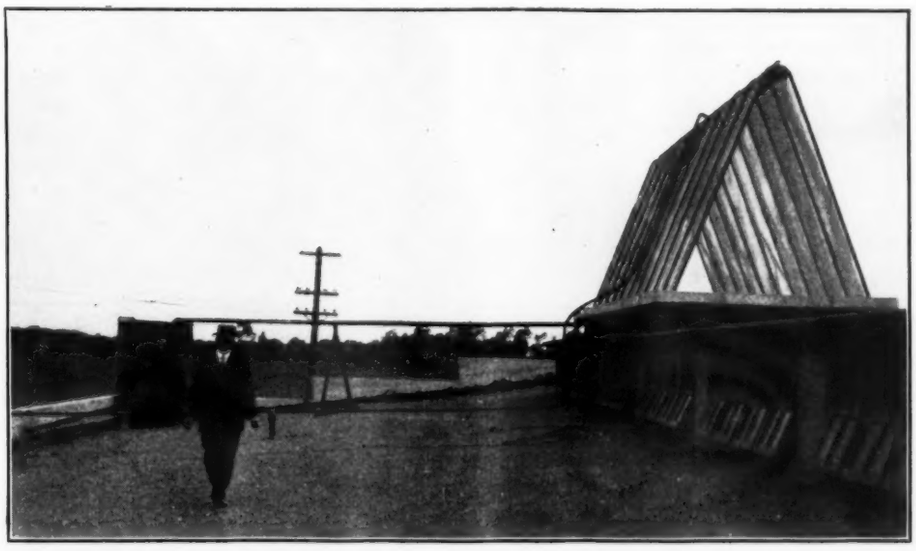


FIG. 1. COOLING TOWER AND TANK ON ROOF

The hot water from the engine jackets is conducted through a 2-in. pipe to the top of the tower at the central point. Into either end of the 2-in. tee is a 15-ft. length of thin galvanized leader pipe, having a line of ⅛-in. holes, which distributes the water over the crown-sheets. The distributing pipes can be easily removed for cleaning.

As the roof of the power house was not designed to support extra weight, it was not thought wise to allow a collection of water under the tower. Therefore a steel tank holding 1,200 gal. was mounted over

the corner concrete walls of the power house; see Fig. 1. A 4-in. pipe drains from the low corner of the catch basin to the top of the tank. Also, as can be seen in the photograph, there is a smaller pipe running up and over the top of the tank. This furnishes the makeup water which is metered and controlled by a float valve. Also, a ball float in the tank connects with an indicator in the engine room, by which means the engineer is advised of the level of the water in the tank.

From the bottom of the tank and running inside the fire wall of the building is a 3-in. pipe which conducts the cooled water down to the engine, the amount of cooling water to the cylinder jackets, etc., being controlled by valves in this line; that is, the feed through the jackets is by gravity from the roof tank.

The various jacket discharges empty into a common open catch tank, as shown in Fig. 2; this allows ready inspection of the flow through the jackets. The catch tank is connected near the bottom to the suction side of a motor-driven centrifugal pump; an overflow pipe near the top empties into the sewer. The circulating pump has no suction lift, as the warm water simply feeds to it by gravity due to the working range of water level in the tank. The pump discharges through a gate valve to the top of the cooling tower (about 50 ft. elevation). An integrating watt-hour meter measures the power input to the pump motor.

The design of this cooling system is such that should the motor-driven pump fail to operate, unknown to the engineer, the cooling will go on automatically. As soon as the pump fails the level of the water emptying into the catch tank will rise and begin draining off through the overflow connection to the sewer. This will decrease the amount of water in the system, and the float valve in the roof tank will open, allowing as much makeup water into the roof tank as is being wasted to the sewer. As soon as the pump goes into commission again, the system will automatically return to its regular operation and the waste will stop.

Through this cooling system the temperature of the circulating water is lowered about 23 deg. F. A thermometer is permanently inserted in the hot-water pipe leading to the cooling tower and another in the 3-in. line leading from the roof tank to the engine room.

The only trouble that has been experienced with this cooling system so far has been the more or less fouling up of the wire cloth by a green growth which takes place. This apparently results from the well water as it comes in contact with the sunlight, the tower being in the open air and not sheltered in any way. Possibly it may be necessary to resort to chemical treatment of the water or shade the tower from the sun. We would welcome suggestions from those who have experienced and overcome similar troubles.

Will Quizz, Jr.

SYNOPSIS—Will Quizz, Jr., notices an engineer restarting an injector by means of a stream of cold water from a hose. He wonders why cooling makes the injector work.

"Say, Chief, you told me one day that it always takes heat to produce work."

"I told you, Will, that the conversion of heat into work always meant a reduction of temperature and loss of heat. What has got you so upset about it, anyway?"

"Why, I was watching that contractor's outfit pumping water out of the new sewer trench. They have an old locomotive-type boiler fed with an injector. The injector overflow began blowing like a soda fountain, but the engineer didn't worry a bit; he simply, sort of careless like, picked up the hose and squirted a stream of cold water onto the injector. This made the overflow choke off with a snap. It was the easiest thing I ever saw, but why did the cold water start the injector? Operating kinks of this kind do not seem to be explained in books."

"Will, lifting injectors, figuratively speaking, are like folks; they get more done when they keep cool. When a pump lifts water from a well, the first necessity is to take the air pressure out of the suction pipe, create a partial vacuum by displacement, and the atmospheric pressure on the surface of the water in the well forces the water up the suction pipe. Then the pump piston takes the water and boosts it to a higher level or into the boiler."

"Yes, Chief, I see the pump stunt, but I can't see the grip action of the injector. It's as immovable and mysterious as a quack doctor."

"There's only one fixed way to produce such action, Will, and that is by securing a partial vacuum. An injector is the same as a pump, but the vacuum is produced by condensation and a jet action. The steam that fills the vessel must be cooled off either by an interior or exterior cooling agency. That's where the loss, or transfer, of heat occurs."

"Oh, I see, Chief! the injector fills with steam, and by cooling this, a vacuum is formed. This reduces the pressure in the suction pipe and the water rushes up like it was glad to get there."

"Sometimes, too much steam is turned on and there isn't enough water, or perhaps none, getting in to condense it, so steam blows through, making the injector extra hot, and there can be no transfer of heat from the steam, and the injector quits. There are two things the engineer can do. The usual way is to cut down or regulate the steam, or he can cool off the injector as you saw, without having to reach to the steam valve. He lazily sprayed the injector until the temperature was sufficiently reduced."

"How, then, does the water get beyond the injector and into the boiler against the same pressure as the steam had originally?"

"The steam rushing from the boiler at a high velocity is condensed by the feed water in the proportions, we'll say, of one pound of steam to fifteen pounds of water, depending on the temperature, and, combined, they are shot forward by the onrushing steam behind, combining weight and velocity."

"As all the steam gets back in the boiler, and injectors thus seem to have an efficiency of 100 per cent., why don't we use them in our plant?"

"In itself the injector is very near 100 per cent. efficient, but in order for it to work, the water must be cold enough to condense the steam readily, and the loss occurs in start-

ing with cold water if there is exhaust steam or other waste heat available to heat it. Economy requires the use of hot feed water, which should be heated by some means other than by heat directly from the boiler. Do you see the point?"

Imperial Type Air Compressor

Because of the wider use of high-pressure and superheated steam there has been developed a balanced-piston steam-valve gear that has been incorporated in the design of the standard "Imperial" duplex air compressor.

The cutoff valves are right and left-hand threaded to a cutoff valve stem. Steam is admitted through the center of the valve (Fig. 1) to the cylinder and is exhausted

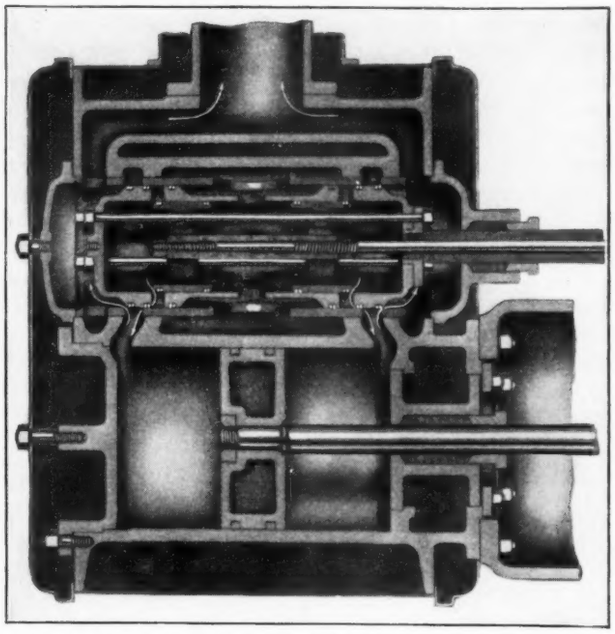


FIG. 1. SECTION THROUGH HIGH-PRESSURE CYLINDER

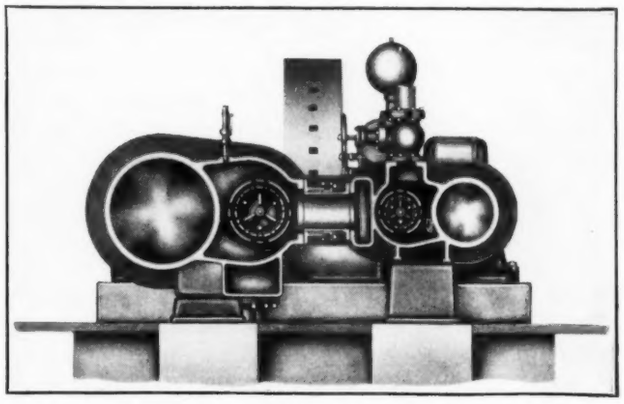


FIG. 2. SHOWING STEAM VALVES AND RECEIVER

around the ends of the valve. The valve-chest covers and steam packings are exposed to exhaust pressure only.

The machine is built with a steam receiver between the high and the low-pressure steam chests, Fig. 2. A special expansion joint guards against destroying the cylinder alignment.

The governor is a speed and pressure regulator which varies the cutoff by automatically rotating the cutoff-valve stem. It is essentially a chain-driven rotary oil pump acting against a weighted plunger. The oil pressure maintained by this pump on the plunger varies with the speed of the compressor, and changes the point of cutoff in the steam cylinders.

The other features of this new compressor, called by the maker "Imperial" Type XPV, are inclosed main frames containing the reciprocating parts, automatic lubrication by the bath system and water-jacketed air-compressing cylinders.

This compressor, built by the Ingersoll Rand Co., 11 Broadway, New York City, is made in capacities from 608 to 3,620 cu.ft. per min. and for discharge-air pressures from 10 to 110 lb. per sq.in.

Louisiana Stationary Fireman's Act Annulled

By A. L. H. Street*

The Supreme Court of Louisiana has annulled the law enacted in that state in 1914, declaring it to be a misdemeanor to employ a stationary fireman more than eight consecutive hours in one day in a city of 50,000 population or more. The act defined a stationary fireman as being "any person employed in the generation of steam in stationary boilers in which coal is used as fuel."

The measure is declared to be unconstitutional as being unjustly discriminatory between employers located in different cities and using different kinds of fuel. (State vs. Legendre, 70 "Southern Reporter," 70.) The court says, in part:

> It is obvious, from the restriction of this statute to the very limited class of "persons engaged in the generation of steam in stationary boilers in which coal is used as fuel," in a city of 50,000 inhabitants or more, that this legislation has no relation to the health or morals or safety of the public, or to the health, morals or safety of the class of persons to whom the statute is confined in its operation.
>
> What reason of public policy can there be for discriminating against the employers of firemen using stationary boilers in which coal is used as fuel in a city having a population of 50,000 or more, and against employers of firemen using portable boilers, or burning wood, coke or fuel oil, or operating in a city having a population of less than 50,000?
>
> A fireman employed at a stationary boiler in which coal is used as a fuel, in a city having a population of 50,000 or more, is not a ward of the state. He does not need the protecting arm of the Legislature, nor deserve its interference with his freedom of contract or independence of judgment, any more than a fireman employed at a portable boiler, or firing wood or coke or fuel oil, or firing coal under a stationary boiler in a city of less than 50,000 inhabitants.
>
> It is the duty of the courts to enforce the state's police regulations enacted by the Legislature in good faith and with reasonable and appropriate regard for the protection which the state owes to the life, health and property of her citizens. . . . But a statute containing a mere pretense of promoting or protecting public health or public safety, and having no real or reasonable relation to its pretended object, is an abuse of the police power of the state, and, insofar as it invades the fundamental rights of her citizens, it is the province and duty of the courts to adjudge such subterfuge invalid.

Cottonseed and Corn Oils are sometimes used in lubricating oils, but have merit only as cooling elements, for thread cutting and the like. Their high specific gravity (92 to 93 per cent.) makes the mineral oil to which they are added deceptive when too much dependence is placed on viscosity.

Cumberland Edison Power Plant—In the table of principal equipment of the Cumberland Edison Power Plant, published on page 709 of the Nov. 23, 1915, issue, no credit is given as to the piping system, which was supplied and erected by the National Valve and Manufacturing Co., Pittsburgh, Penn.

*Attorney at law, Security Building, Minneapolis, Minn.

The Displacement of Ammonia Compressors

By Peter Neff*

SYNOPSIS—The author points out the advisability of discriminating between the terms "swept volume" and "effective displacement" as applied to ammonia compressors.

It frequently happens that terms are used which have a definite meaning, but which may be misleading when used indiscriminately. "Compressor displacement" is one of these.

When a solid object such as a stone is immersed in water, a given amount of water is said to have been displaced and this is the same as the volume of the stone. In water pumps the plunger truly displaces a given amount and pumps are rated with reference to the amount of displacement produced. Assuming an absence of leakage about the plunger and knowing its size, it is easy to calculate the amount of water that should be delivered. A piston, by moving through a cylinder, produces the same effect as a plunger, and the volume displaced is measured by knowing the area of the piston and the distance through which it moves in a given time. All this is simple and is known to everyone that operates a pump.

One hears salesmen and engineers talk of the displacement of the ammonia compressor in a way to imply that it thereby indicates the amount of gas taken in and discharged. Here is where the term "displacement" is inadequate to express what is meant.

Capacity in Terms of Displacement

While it is true that a compressor has all the characteristics of a pump and is frequently referred to as a pump, such a conception of it may lead to erroneous conclusions. We assume in the case of the compressor as in that of a water pump, that there are no leaks and will agree that displacement is measured by the area of the piston multiplied by the distance traveled in a given time. This is sometimes spoken of as the "swept volume" of the piston, and if we are going to adhere to the use of the word "displacement" as indicative of the capacity of a compressor, then we had better use the term "swept volume" to indicate what is meant by displacement.

One engineer will say to another, "I am producing a ton of refrigeration with 7,200 cu.in. displacement." The one addressed replies, "Is that so? I require 9,000." And immediately the presumption is made that one machine is better than the other.

It is possible that the one with the 9,000 cu.in. is producing a ton of refrigeration with less expenditure of energy than the one with the 7,200 cu.in. These two men have based their calculations on the "swept volume."

Certain things are peculiar to the compression of a gas. We all know that the piston cannot touch the heads, and that ordinarily, at least, there are some pockets where the valves are located. In the case of water these clearance spaces, as they are termed, have little or no effect on the amount of water that the pump will discharge; with a compressor, at the completion of the stroke the clearance space is filled with the gas under pressure, and as the piston recedes, instead of this gas remaining at a constant volume, as would water, it begins to expand as the pressure exerted by the piston reduces. It is evident that the suction valves that admit the gas into the compressor will not open until the pressure inside the cylinder is at least the same as that in the suction line. The distance traveled by the piston before the suction valves open is a measurable amount of the swept volume. The remaining distance the piston travels is the only part of the swept volume that can be filled with gas from the suction line. The amount of refrigeration depends, among other things, on the volume of the ammonia that is taken in from the suction line. So that while one compressor may have a much greater swept volume than the other, it may not have what, for want of a better term, we may call effective displacement. If one machine were doing the work of one ton of refrigeration with 7,200 cu.in. of effective displacement and the other requires 9,000, then there might be a disparity between the two. But all too often displacement is spoken of without adequately qualifying the term.

Effective displacement means much, swept volume little, when it comes to comparing compressors, and yet this is continually done. And while all this description seems to be so rudimentary that everyone knows it, yet it is one of the sources of much misunderstanding, and a salesman in arguing for his compressor may, by the use of the word "displacement," perhaps unconsciously, convey to his hearer an impression of the capacity of his compressor that is not in keeping with the facts.

Weight of Gas Determines Capacity

Formerly it was strongly argued that a compressor that had but little reëxpansion loss—that is, small clearance spaces—was a more efficient machine than one that had a greater amount. The term efficiency may mean much or little, depending on what ratio is meant by it. The less clearance there is, the greater will presumably be the capacity of the compressor, but it is not thereby necessarily more efficient, when efficiency is taken as the ratio between energy expended to operate the compressor and the refrigeration produced.

The purchaser of a machine is not so much interested in the actual size of the compressor as in the horsepower per ton that the machine will show.

It is a further fact that the compressor with the greatest amount of what we have called effective displacement may not be capable of taking in as much gas from the suction as one with less; because in one the suction gas, which is at a low temperature, may, by coming more intimately in contact with parts of the compressor that are at a higher temperature, thereby become superheated, so that a given weight of ammonia occupies a larger volume. The amount of work done is dependent upon the weight of the gas handled, therefore that compressor which for a given effective displacement takes in the greatest weight of gas may be considered as more effective.

*Consulting engineer, Canton, Ohio.

Editorials

Some Pointers in the Purchasing of Power

Frequently, where a concern decides to change over from private to purchased power or to supplement its present capacity with power from an outside source, the engineer, if retained, can be of service to his employers by helping them obtain a satisfactory contract. Many plant owners know next to nothing about the purchase of power beyond the price agreed upon, and this affords a real opportunity for the capable engineer to demonstrate his worth.

The power company may attempt to demand that the prospective patron sign a contract binding him to receive service from the utility for a certain period of time, perhaps also requiring several months' notice before discontinuing the service. In many sections if a new consumer appears and demands service, he naturally must bear the expense of connecting his plant with the company's transmission system; but this being done, whether the consumer then uses energy for a longer or a shorter time, the utility is in no wise injured. Of course the parties have a perfect right to enter into an agreement to sell and receive energy for a stated period, but unless it can be shown that the power company will be obliged to make a substantial investment to take on the business, the prospective customer should not hesitate to ask for service for an indefinite period, if he wishes a free hand.

Again, the natural desire of the power company to bind the consumer to its own system should not prevent the engineer from advising his employer to stand out for the right to take energy from whatever source desired, so long as the installation does not jeopardize the quality of service rendered other customers of the utility company. And the entire right of the customer to maintain a standby plant of his own should not be questioned; in fact, if a reciprocal power contract can be entered into whereby shortages of water can be made good by the delivery of energy in reverse direction from the customer's plant into the system as a whole, the arrangement in many cases may turn out very profitably for all concerned.

Trouble has sometimes been experienced through neglect of the purchaser to provide for the delivery of energy in bulk at a central metering and distributing station where the full benefit of the total energy consumption can be reaped in lower rates. Such combination of loads for billing purposes is entirely legitimate and is usually cared for in concerns where a thorough engineering analysis precedes the signing of the power contract, but the keen-sighted engineer will strive to require the power company to meet the high-tension distribution investment cost of such an installation where the monthly bills are substantial and where such cost is not excessive in proportion to the business.

Another point deserving careful study is the metering of energy on the primary or the secondary side of the power transformers, which is generally closely related to the ownership of such equipment. It is well to get figures from the power company as to the running cost of each method and to determine by personal investigation the reliability of such estimates and the more desirable arrangement. Other points that may be overlooked are the right of the customer to install equipment in his establishment to transform the energy supply as to phase, frequency and voltage, or for use at the customer's pleasure in lighting, power or heating service; the right of the customer to sell his apparatus without turning over to the power company a contract for service to be taken by the purchaser or assignee; the responsibility for the installation and cost of local safety devices; penalties for interrupted or below-standard service; and methods of testing meters and of arbitrating any disputes that may arise.

Seeing More Than the Trouble of the Moment

Like a toothache in the night, any plant trouble tends to monopolize the executive engineer's attention. When something goes wrong and insistently demands looking after, it is obviously no time to go to work on one's annual report of output and cost, but there is such a thing as flying to an extreme of concentration upon petty difficulties and failing to take a large view of operating incidents. Here is where confidence in one's subordinates should be turned to account.

Local conditions naturally control each situation, but the engineer that has a staff of competent and therefore of thinking subordinates has no excuse for getting excited over a great many situations that arise in the course of a year's operation. It is one thing to know that everything possible is being done to remedy a situation and another to act upon the apparent belief that the only proper course is to grab the necessary tools and do the work personally. In the small plant this may be necessary, but there are many stations where a little more personal detachment on the part of the chief from the actual handling of the minor repairs or readjustments required is a good thing.

The higher one rises in industrial organization the more one finds that the larger salaries are paid for judgment combined with executive ability. The moment an operating situation tends to get away from the capacities of the men immediately handling it, the superior authority must step in and take command of the detailed execution of instructions. Very likely he may have to take off his coat and bear a hand in person at some critical time, but this is different from elbowing one's assistants out of the way when some minor trouble arises that is entirely within their knowledge and experience to handle properly. A certain superintendent of construction will, if occasion demands, jump into a manhole on a muddy night, even when clad in a dress-suit, but with the perfection of his organization in recent years

this kind of activity has become virtually unnecessary—and the service is restored just as quickly, which is the nub of the whole thing.

The engineer that maintains a complete command of the entire situation in the event of operating troubles is the one that is respected. As a class, engineers keep their nerve exceedingly well in the face of many trying circumstances. It is the abnormal occurrences in operation which test one's fitness for such command; and the ability to see beyond the immediate happening, to summon the lessons of experience and study into the situation and master it by refusing to be "balled up" by purely local disturbances is worth striving for. It all goes back to that sense of perspective which draws the sharpest line of cleavage between the expert and the layman. Self-training will accomplish a great deal in this field, for by it the diligent student of power production in all its phases capitalizes his experience, improves his ability to diagnose faults in equipment and personnel, and thereby points the way out of difficulties, which are taken at their face value and handled, in the words of the great Bismarck, "without haste—without waste."

The Low Cost of "Efficiency-Promoting Devices"

Apparatus capable of increasing the efficiency of power-plant operation would be purchased oftener if owners realized what a small part of the total plant investment it usually figures. Many engineers have experienced the difficulty of convincing an employer that spending one or two hundred dollars for testing appliances will prove profitable. The best results are obtained by employers that hire competent engineers and then leave to their judgment matters on which they are better qualified to pass. Every problem cannot be solved mathematically, and the owner that expects mere computations to take the place of judgment where calculation must be based largely on assumptions, fails to "cash in" upon the ability of his engineer, given the right sort of man behind the throttle.

A few examples of the cost of what might be called "efficiency equipment" are illuminating. In one plant of four thousand kilowatts' capacity the total equipment cost $420,461. The apparatus that might be listed under "efficiency-promoting devices" included an oil- and waste-saving machine at $155 and two oil purifiers at $194 each, installed. Here was a total outlay of one-eighth of one per cent. of the plant cost for apparatus which was not absolutely essential to the conduct of the station, but which was bound to be a decided factor in reducing its yearly running expense, given intelligent foresight in design and selection. In another plant of about three-thousand kilowatts' rating, the total cost of machinery, boilers, etc., was $313,000. Looking through the list of auxiliary apparatus one finds a special water meter at $500, a carbon-dioxide recorder at $300, two steam-flow meters at $72 each and another oil- and waste-saving machine at $160. At an outlay, therefore, of about $1,100, or about one-third of one per cent. of the cost of equipment exclusive of the building, the station was provided with several devices useful in checking detailed performance and in helping to secure the prompt detection of elusive losses.

The engineer that puts it up to his employer in this way should find it less difficult in certain instances to obtain the necessary appropriation, particularly in those instances where the executive of the property is sensible of the proportional value of expenditures. An employer that will deny his engineer the authority (and funds) to provide a gage-testing outfit at $75 or some other apparatus locally needed in the interests of real economy, cannot expect that his total costs will be the envy of his competitors.

The mere fact that a given device costs a small percentage of the total plant investment does not justify buying it unless the judgment of the engineer so decides, but when the relative investment is so small persistent begging for it should be unnecessary.

Writing Technical Reports

To be able to express oneself correctly and tersely on paper is an asset second only to possession of the knowledge which it is desired to impart. This applies especially to the engineer, whether of the operating, consulting or managing varieties; for there are times when an intelligible report on the performance of a plant, the results of a test or the adaptability of a manufacturing process will go far toward establishing a reputation.

According to an item in the *Electric Railway Journal*, the Massachusetts Institute of Technology has recently added to its curriculum a course in "Report Writing." This commendable step should be followed by other technical schools and should be made mandatory, not elective.

The student before entering college is presumed to have had a thorough grounding in English, but a perusal of the average student's laboratory report leads to the suspicion that the preparatory schools are paying too much attention to so-called fads and irrelevant subjects to the neglect of the three "R's." Some technical schools, recognizing this defect in the preparatory training, provide a course in English to supplement the technical course. This is undoubtedly beneficial where the time permits, but what the engineering student needs is not so much the acquirement of a literary style as the ability to record concisely what he observes. A course in Report Writing should meet this requirement.

The Results of Locomotive Boiler Inspection

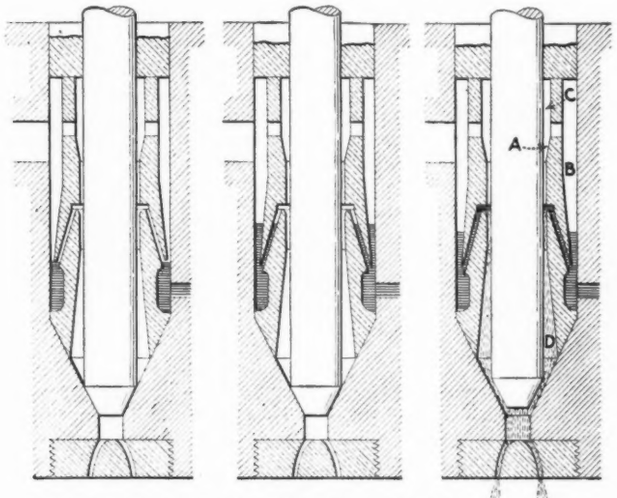
The annual report of the chief inspector of locomotive boilers for the fiscal year ended June 30, 1915, has just appeared. In four years of service the annual number of accidents has been reduced from 856 to 91, the number of persons killed by such accidents from 91 to 13, and the number of persons injured from 1,005 to 467. Even during the past year 32,666 locomotive boilers and their appurtenances were found defective, and 2,027 were ordered out of service. In the face of facts like these there are those who oppose such inspection and supervision as an unwarranted interference.

The average rate paid for domestic electric service in the district served by the Hydro-Electric Commission of Ontario is less than four cents per kilowatt-hour, and this after the commission has paid a profit on the juice to the Ontario and other power companies.

Correspondence

Method of Operation of the Hesselmann Fuel Nozzle

I was very much interested in reading the admirable description of the McIntosh & Seymour Diesel engine in your issue of Nov. 30. Pointing out the fact that the man on the platform has the whole plant below him, shows indeed, the simplicity of the Diesel engine. What I want to ask is, why this cry for simplicity? Is the Diesel here as an engine for the efficient generation of power or chiefly as an example of simplicity? The late Colonel Meier, when they were first bringing the Diesel engine out in this country, made the usual general statements about the efficiency of the engine and then said that of course when the engine got into the hands of the practical engineers it would be stripped of its trappings and whipped into practical shape. All I can say is, God help any



SHOWING OPERATION OF HESSELMANN FUEL VALVE FOR DIESEL ENGINES

Injection stroke completed. Valve just closed | Fuel-pump stroke completed. Valve still closed | Working stroke of engine. Valve open, feeding fuel

engineering device which falls into the hands of the American "practical engineer."

The steam engine has its condensers, feed-water heaters, economizers, etc. Would you eliminate these in the effort to simplify the steam engine? Certainly not if the engine was designed for use. It would seem to me more to the point for the manufacturers to try to utilize some of the waste from the engine. Complicate the engine along thermodynamic lines so as to get all there is in the engine out of it. Practically 10 per cent. of the power of the engine is utilized in the production of injection air. One-half of this is all that is needed for this work.

The statement is made in the article referred to that the charge of oil is deposited in chamber *C* of the fuel valve and that it does not fill this chamber even at full load. This fuel valve is an inclosed device, and no way is shown by which this point can be settled. The description says: "Its essential feature is that, instead of pulverizing the oil by crowding it down through perforated plates, it draws it by the injector principle into the current of ingoing injection air." Your attention is called to the description of the same feature in the "Neuere Rohölmotoren," by Ch. Pöhlmann, published in 1912. This is nearer the home of the device than McIntosh & Seymour, who get the same thing from the same source, but only after it has filtered through the hands of the "practical engineers" of Sweden. Fig. 60 of this book—reproduced herewith—shows the valve in three conditions. Evidently one is at the end of the fuel injection. The next is at the end of the pump stroke, and the third is at the beginning of the injection stroke. This explanation has reason behind it, and since no one can tell what happens in the valve, I for one prefer to "chew my own food." It looks as if the valve was designed with this in view. The passage which I have marked *A* opens directly into the cylinder. This passage is narrow, and when the valve is open there is a difference of pressure at the two ends of *A*. At the end *D* this pressure will be less than at *C*. Now *B* is in communication with *C* at one end, but sealed by the oil charge at the other end. For this reason when the valve unseats, the oil is forced out of its reservoir by reason of the difference in pressure. What could be more simple? The object of the baffles mentioned, in reference to other valves, is simply to prevent the oil from entering the cylinder in the form of a slug, as I have had trouble with its doing in my experimental engine.

I have gone all through this trouble and have discarded all these complications. The weak point in this valve is that the difference in pressure which is needed to lift the oil into the current of the air is dependent upon the size and shape of the passages in the valve. It stands to reason that the valve should be designed for the fuel to be used. I have developed a valve in which there are but two passages. One is for oil and the other for air. The oil being fed by a hydraulic pump unlimited power, so to speak, can be used to force the fuel into the air. The air will do the rest so long as the oil is forced into its moving current.

When the operating engineer is filled full of such abstruse and untenable theories as this one of the fuel valve, is it any wonder that he approaches the Diesel with fear and trembling? If I had to depend upon much that is written about the Diesel I would stake my life that the engine would not turn over. (As a fact you are no doubt aware that no engine constructed upon the real Diesel theory has ever turned over yet). I take my hat off to the so-called Diesel which, up to date, is "King of them all." The steam electric plant cannot show an efficiency of over 11 per cent. at the best, while the oil engine can show better than 20 and probably around 25 per cent. now. This includes a loss of probably more than 1 per cent. in the injection air alone. Besides this, the waste heat is thrown away. This can be utilized to run auxiliaries under ordinary service conditions and to furnish a reserve for the peak loads. When the oil

engine is approached from a thermodynamic standpoint, how long can the present steam plants, with all their refinements, withstand the onward march of this line of development? To bring about this condition the oil engine must be understood and taught as a thermodynamic machine. It must not be described for its simplicity. Simplicity is all right for the sawmill plant running on slabs at places where slabs have no value and the engineer is of the sort which your front-page cartoons have been trying to lift out of the rut into a better understanding of his field.

I feel that the boys in the engine room will be interested in this new type of plant and will be able and willing to rise to the situation. They always have so responded, and there is no reason why they will not do so now. Another point concerns the owner. He wants to save money. Will it not be easier to interest him in the project of a new investment in machinery when you approach him with a plant that has thermodynamic laws behind it than when you approach him with a device and tell him it works and he must take your word for it? If it is a blind game, how is he to be able to reckon on upkeep, repairs, etc.?

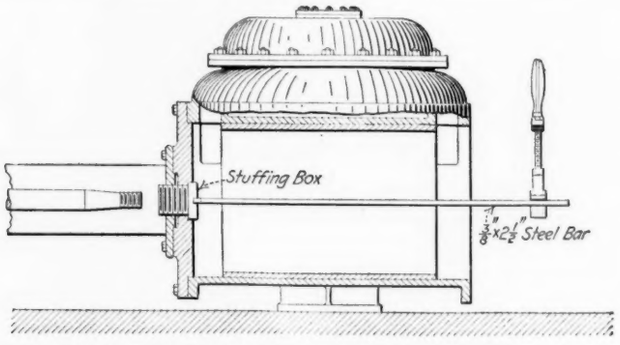
This communication is not intended as a criticism of *Power*, to which I am much indebted for many kindnesses in the past 15 years while I have been on this line of work. It is intended as an eye-opener for manufacturers, operators and purchasers. My faith in the oil engine is unlimited. JOHN F. WENTWORTH.

Quincy, Mass.

Removing Pump Stuffing-Box

The illustration shows how the stuffing-box was removed from the water end of a large vacuum pump and also its construction, being threaded and screwed through the cylinder head from the inside. The $\frac{3}{8}$x$\frac{3}{16}$-in. slot across the end is to be used in screwing it through the cylinder head—an easy matter before the pump is assembled.

Tightening the nut on the outer end of the stuffing-box tends to unscrew the bushing into the cylinder, hence it



UNSCREWING BRASS BUSHING WITH LONG BAR

must be screwed into the cylinder head exceptionally tight and is usually put in with a pipe-joint cement or white lead to prevent possible leakage. The difficulty in trying to remove the stuffing-box by inserting a $\frac{3}{8}$x2½-in. by 3 ft. steel bar in a rough slot only $\frac{3}{16}$ in. deep may be imagined, especially since the threads on the outside of the cylinder had been badly treated and had to be dressed up with a three-cornered file before they would pass through the cylinder head.

Labor alone on this job cost $8. I consider this a poor design, as the stuffing-box could have been put in from the outside just as well, having a square nut to turn it by, so that it would only be necessary to remove the piston rod to take the stuffing-box out easily and quickly, without destroying the packing on the piston. Then, too, there would be no danger of backing it into the cylinder when the follower nut was screwed up tight.

Cambridge, Mass. R. A. CULTRA.

The Lubrication of Cylinders and Bearings

To operating men F. L. Fairbanks' article, "The Lubrication of Cylinders and Bearings" in the Dec. 7 issue was interesting and valuable. Boring the bearing larger than the shaft or journal is good practice if one does not overdo it and reduce too much the bearing surface. I bore the bearing from $\frac{1}{64}$ to $\frac{1}{32}$ in. larger than the journal or pin, depending on the diameter, then I cut away the bearing's lower half by scraping, filing or with a shaper, but only on the oil-inlet side.

If the journal is to rotate sometimes in one direction and sometimes in the other, the other side of the bearing would be cut away. The quarter-boxes (Mr. Fairbanks terms them cheek pieces) are similarly cut away. I also bevel the edges of the top half of the bearing. It is just as necessary to bevel the "scraping edges" of the crankpin and crosshead-pin boxes and the guide shoes, and particularly so on the bottom half of a crosshead-pin box of a vertical single-acting ammonia compressor. If this box is a true fit to the pin, oil cannot get between the pin and the bearing surface. The piston, piston rod and crosshead are heavy enough to come down without a pull from the connecting-rod, as the reëxpanding gas gives them a start downward, and the pin and its bearing are in contact at all times. If this bearing is slightly larger than the pin, oil will be dragged beneath the box and pin by the semirotary movement of the pin; a beveled oil groove will accomplish this as long as the groove has a bevel. But this bevel gets worn down and forms a sharp edge, which scrapes the oil off instead of forcing it beneath the pin.

It is necessary that the edges of the quarter-boxes of a horizontal engine or compressor be beveled because they are under a greater pressure than the bottom box, and if they had a sharp edge the oil would be scraped off. Take Mr. Fairbanks' low-pressure 60-in. cylinder and assume that it has 30 lb. initial pressure. The total pressure on the piston at the beginning of the stroke will be $60 \times 60 \times 0.7854 \times 30 = 84{,}823.2$ lb., say 42 tons. If this engine is horizontal most of this 42 tons will be on the quarter-box as well as the piston, which will be more than the weight per square inch of the flywheel and journal on the bottom box. When the engine is run "over" the angle of the connecting-rod has a tendency to lift the journal off the bottom box.

Mr. Fairbanks gives the piston a most unusually large bearing surface, which is good, but he does not seem to be consistent, for he decreases the surface on which the shaft bears.

I do not know how successful the threading or grooving of a cylinder and piston will be. I have never tried it, but it looks like a good means of promoting lubrication. However, I do not intend trying it on my em-

ployer's compressor. And the only thread I intend to cut on an ammonia piston rod is that which screws into something—the crosshead, spool or piston. Surely not where the rod makes contact with the packings. Ammonia costs 35c. per lb. here in Arizona.

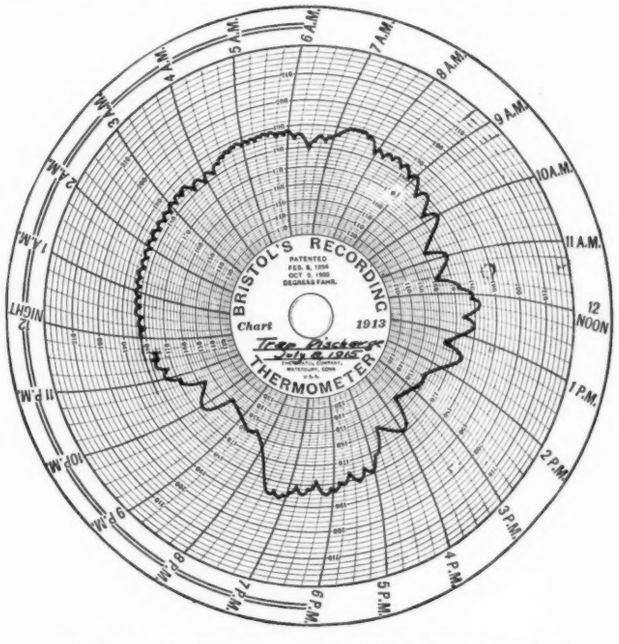
I make an ammonia piston 0.012 in. smaller than the cylinder, a steam piston 0.010 in. smaller. The ammonia cylinder being water-jacketed is the reason for the difference. I make the snap rings 0.002 to 0.003 in. smaller than the cylinder, cut them and spring them together, and then turn them.

There is no doubt that water travels in front of the piston in the low-pressure cylinder mentioned by Mr. Fairbanks if the engine is running condensing; but I cannot believe he found the cylinder oil floating on top of this water; at least I have never found a cylinder oil that would separate from the water so easily. On the contrary, I have found it difficult to drive it to the top under favorable conditions. It would seem that this water and oil mixed would have a tendency to wash the bottom of the cylinder free of oil.

Winslow, Ariz. GEORGE J. TROSPER.

Draining of Pipe Lines

About the time that the article, "Draining High-Pressure Steam Piping," by Charles L. Hubbard, appeared in *Power*, Nov. 2, 1915, I had particularly interested myself in this subject as practiced at our plant. In dealing with steam separators Mr. Hubbard mentions experiments



RECORD OF DISCHARGES FROM A STEAM TRAP

which showed that they may do the work effectively while the steam velocity is low, but have little effect when the velocity is increased to 5,000 ft. or more per minute. We have had an interesting example of this in a case where it was suspected that the steam furnished to a turbine was not as dry as it should be.

There was at that time no connection for a calorimeter, so the best we could do was to watch the trap discharges. This was a nuisance, as the trap was of the bucket type and had to be left to blow out on the floor and the discharges counted. The night engineer overcame this difficulty by taking an old recording thermometer, hanging it in a convenient place and attaching the bulb directly to the outside of the trap discharge pipe and then covering the bulb and pipe with asbestos. The heating of the line whenever the trap discharged was recorded on the chart, giving the separator and trap performance. One of the charts is shown herewith. During light load and when the turbine is not running, the trap dumped frequently. During heavy loads it discharged about once per hour, showing that the high velocity of the steam carried most of the moisture with it.

Later on, a calorimeter was attached to the steam line, and it was found that the average moisture content of the steam after it left the separator was 1.3 per cent.

The recording thermometer has been left connected to the trap line, as the chart will also show whether the trap is working properly or blowing through. When the trap is blowing through, an even line is made by the pen at the same height as the small peaks. The chart does not necessarily show the true temperature of the trap discharge, because the bulb of the thermometer does not come in contact with the water.

Mr. Hubbard shows a "typical method of draining the steam jacket and receiver of a compound engine." I cannot see the advantage of trapping condensate into the shell of the receiver and then trapping it out again to the hotwell. True, a part of it will flash into steam and be used in the low-pressure cylinder, but in a well-proportioned engine the high-pressure cylinder should furnish enough steam to hold the proper receiver pressure. The drips from the steam jacket and reheating coils give pure hot water, which should be returned directly to the boilers or feed-water heater. By trapping it to the shell of the receiver, it will mingle with the mixture of oil-laden steam and condensate from the high-pressure cylinder, and will thus become useless for boiler-feed purposes. GEO. A. WEINDEL.

Covington, Ky.

Sudden Cooling of Boilers in Cases of Low Water

The stand taken by R. N. Blackburn, *Power*, Nov. 16, 1915, p. 696, in defense of the rules laid down in the bulletin of the Steam Boiler Inspection Department of Saskatchewan that the safest practice when low water is discovered is to "shut the damper, open the fire-door and start the feed pump," is one that is opposite to the procedure prescribed by most boiler laws and one that is opposed to the instructions received by nearly every engineer and boiler inspector.

The danger of Mr. Blackburn's article is that it may cause some engineers and firemen to underestimate the dangers of low water and to become careless in keeping the water level up to a safe height, although he does not wish to convey the idea that a hot crown-sheet is not dangerous.

The crown-sheet in locomotive-type boilers, as Mr. Blackburn states, is more likely to become overheated than any other part of the boiler, as it is submerged but a few inches at normal water level, and the danger of overheating would be confined to this point because the tubes, being lower, are still submerged when the sheet is bare. In the tubular and water-tube boilers the tubes

are the first to become overheated from low water. This will allow them to sag and sometimes to pull out of the heads or become so badly burned that they will burst from the pressure when red hot. Admitting cold water under these conditions would not fracture the shell, but would cause every tube in the boiler to leak, which might not happen if the boiler was cooled down gradually. The resulting water-hammer caused by turning cold water into a red-hot boiler might fracture the plate, and in a boiler with cast water legs, might cause them to fracture.

Hyattsville, Md. J. C. HAWKINS.

Sealing Water Used in Boilers

In a steam-turbine station the glands of the main units and of the auxiliaries were sealed with city water, which finally flowed to the sewer. The cost of this water was quite an item, and after some thought a receiver was placed on the basement floor and all the seal water drips led into it. Then the surface condensers were drilled and tapped and a pipe led from the receiver to each condenser. A check valve was placed on each pipe close to the condenser and a globe valve on the receiver side of it, so that in the event of any condenser being shut down or losing its vacuum, it would not affect the others.

An outlet near the top of the receiver was piped to the sewer; a water glass was also put on the receiver. A float and valve were fitted to the end of the outlet pipe in the receiver and adjusted so that the bottom of the outlet was always water-sealed. This safeguarded the condensers from getting air from the receiver.

When in operation the water is drawn from the receiver into the condensers and is pumped by the wet vacuum pumps into the open feed-water heater, and from there through the feed pumps to the boilers. If the plant were running high pressure the overflow pipe would permit the seal water to run to the sewer, so the outfit requires little attention, yet makes a tank pump unnecessary.

Somerville, Mass. JOHN M. COLEMAN.

Making System a Habit

Having to use a system of any kind in my work was rather "against the grain," but that is just what I was forced to do by a company for which I was engineer some time ago, and now I am very grateful.

Their system has become a habit with me. It consists merely in putting the different details of the work, such as the regular routine, recommendations, purchases, etc., in writing, and this record can be referred to at any time and it saves a great many misunderstandings.

The manager that so forcibly impressed this system on me had a saying that "every man's forgetter is a great deal more efficient than his rememberer" and that the engineer was no exception.

A little book about 4x6 in. with the date at the top of each page was furnished me, and I filled in whatever routine work I had to do. For example, on the first of each month I made a report on the condition of all elevators, boilers, sprinkling systems, etc., and on the 10th I read all electric, gas and water meters and recorded all in their proper places for the year.

When something was to be done on some future date, I entered it in the book, and each morning I turned to the page for that day and by night tried to have it all checked off as finished; if I failed it was carried forward to the next page. When I made a recommendation to the manager regarding a purchase or change of any importance, I made a note of it in the book and kept a copy for myself.

So much satisfaction was derived from this habit that I gradually brought in the smaller details of the work, such as packing all valve stems on the heating system once a year, tripping the automatic valves on the sprinkler system every six months; in fact, every part of the equipment had its regular day or days for inspection.

Some might think this made more work, but on the contrary it cut the work about in half. It is better, for example, to inspect and patch the brickwork around the boiler every two months than to let it go six and then have it all to renew; or to clean the commutators on all dynamos and motors regularly than to let them go and then have a shutdown and expensive repairs.

It is much better to regard the boiler, elevator or other inspector as a welcome visitor than to "duck," hoping he won't find what you have neglected or forgotten to do.

The same method should be used in purchasing material, and all guarantees made by salesmen should show plainly on the face of the order as well as on the stub or duplicate. This will save a great deal of misunderstanding, as some will verbally guarantee anything.

Most employers would appreciate such a system in their mechanical department, and it is a great deal better for the engineer to start the system in a modest way himself, gradually let it grow and then bring it to the attention of the employer, than to have it thrust on him as I did. In either case he won't want to get away from it after using it conscientiously for awhile.

Kansas City, Mo. H. G. SCHULER.

Two Examples of Bad Erection

A new 1,000-kw. G. E. turbo-generator set gave trouble when first started, from heating and vibration. A test level tried on the leveling pads showed that the bedplate was sprung down in the middle, both ends being high. When the coupling was disconnected it had an opening nearly 0.03 in. at the lower side. It was necessary to take the grouting out and re-bed the machine and it was found that no wedges had been used to support the middle pedestal. Fully a week's time was lost, but fortunately no damage was done.

After getting the generator in order the Le Blanc condenser began to fail when the turbine started, although the lines had tested out satisfactorily. A wet place just outside the building aroused suspicion, and a gang of "hunkies" was set to work digging down to find the cause. As this work progressed, the vacuum gradually dropped and finally it was lost entirely, and at the same time the excavation was flooded with water. The cause was found to be a break in the 14-in. cast-iron supply line to the condenser, and as the digging progressed more and more air had been taken in until the vacuum was lost and the water rushed back through the break; the foot valve on the pipe end in the pond preventing it getting out that way. The cause of the break in the pipe was the weight of a concrete waste pipe laid across it and not properly supported. Both the turbine and condenser behaved well after correcting the erection faults.

Pittsburgh, Penn. D. N. MCCLINTON.

Inquiries of General Interest

Revolutions of a Pump—What is meant by revolution of a steam pump? E. R.

The term is used to designate one complete cycle of the reciprocating parts. The number of revolutions made by a pump is readily found by counting the number of repetitions of movement of any moving part, such as one of the crossheads.

Swing Radiators—What are swing radiators, and when are they employed? W. F.

Swing radiators are usually made in the form of single-column cast-iron radiators provided with glands and stuffing-box connections for swinging the radiators clear of walls for cleansing or other purposes. They are intended chiefly for hospital use or in situations where a stationary radiator would be objectionable.

Regulation of Boiler Feeding with Power Pump—How is the rate of feeding a boiler with a power pump regulated? M. C.

The speed of belt-driven power pumps is sometimes varied by cone pulleys for obtaining different speeds of the countershaft from which the pump is driven. The rate of feeding is usually regulated by adjustment of a valve in a bypass for discharging part of the delivery of the pump back into the suction.

Setting of Dished Heads in Steam Drums—Why are boiler drums that are provided with dished heads frequently made with one head set concave and the other convex? J. S.

The head that is set to receive pressure on the concave side is riveted to the shell in the usual manner, but when the drum is closed up by riveting the other head and no opening has been left for admission of suitable means for holding up the rivets during the process of riveting, it becomes necessary to place the flange and concave side of the head toward the outside of the drum.

Paper for Metallic Pencil Points—How can paper be prepared on which a metallic pencil point can be used for automatic recording instruments? J. R. P.

Any ordinarily good quality of paper can be prepared for use with brass pencil points by applying to one side of the paper a thin coat of a mixture of about one part (by weight) zinc oxide, four parts water and one-tenth part gum arabic. The coating should be applied thin and evenly with a brush like a broad varnish brush and allowed to dry thoroughly before the paper is used.

Trouble from Indirect Stacks—In gravity-return low-pressure steam-heating systems, why is it generally more difficult to secure good circulation in stacks or coils used for indirect heating than in other radiators of the system? J. W. C.

Trouble is most commonly experienced from not having the boiler water line far enough below the stack or coil to provide a hydraulic head of the return water from the stack that, with the reduced pressure in the stack or coil, is sufficient for overcoming pipe friction and for discharging the condensate against the pressure of the boiler.

Heating Surface of Standard-Weight Steam Pipe—What is the amount of heating surface per lineal foot and the number of lineal feet of pipe per square foot of heating surface of ¾-in. to 6-in. steam pipe used in steam heating? J. J. C.

The outside dimensions of iron and steel pipe of standard weight, such as ordinarily used in steam-heating jobs, and of the sizes mentioned are as follows:

Size or Internal Diameter in Inches	External Diameter in Inches	Square Feet of Heating Surface per Foot Length of Pipe	Lineal Feet of Pipe per Square Foot of Heating Surface
¾	1.050	0.275	3.637
1	1.315	0.344	2.904
1¼	1.660	0.434	2.301
1½	1.900	0.497	2.010
2	2.375	0.622	1.608
2½	2.875	0.752	1.328
3	3.500	0.916	1.091
3½	4.000	1.047	0.954
4	4.500	1.178	0.848
4½	5.000	1.309	0.763
5	5.563	1.456	0.686
6	6.625	1.734	0.576

Aperture for Measuring Steam Delivered to Tenant—What is the best form of aperture for measuring steam delivered to a tenant? W. C. R.

The best form of aperture is what is known as an "aperture in thin plate," because this form is easiest to determine or to duplicate, and there is less discrepancy between the coefficients recommended by different authorities on account of greater uniformity obtainable for that form of aperture. For insertion in steam-pipe lines up to 1½ in. diameter, an aperture in thin plate is most conveniently provided by drilling the desired size of hole through a disk of sheet steel not over ⅛ in. thick and inserting the disk between two flanges in the steam line. For obtaining conditions more nearly identical with those upon which the most reliable formulas of flow have been based, the line, for a distance of about 2 ft. on each side of the aperture, should be not less than about four times the diameter of the aperture, with provision for good drainage of any condensation. As the rate of flow depends upon the pressure on each side of the aperture as well as its size and form, those pressures should be obtained by observation of the indications of accurate pressure gages connected with the line at a distance of 6 to 10 in. each side of the aperture.

Steam Consumption from Diagram of Compound Engine—In computing the steam consumption of a compound engine from an indicator diagram by the formula which was given on page 695 of the Nov. 16 issue, should the diagram of the low-pressure cylinder be considered, and if so, how is the high-pressure cylinder taken into account? F. B. Q.

The computation may be based upon a diagram from either cylinder, provided the value of "m.e.p." which is employed is the sum of the equivalent mean effective pressures referred to the cylinder whose diagram is used for the computation. Where the computation is based upon the diagram of the low-pressure cylinder, then that m.e.p. of the low-pressure cylinder that would be equivalent to the m.e.p. of the high-pressure cylinder is found by dividing the latter by the ratio of the cylinders. Where, as most commonly is the case, there are the same number and length of strokes in each cylinder, then the m.e.p. of the high-pressure cylinder referred to the low-pressure cylinder is found by dividing the square of the diameter of the high by the square of the diameter of the low and multiplying the quotient by the given m.e.p. of the high-pressure cylinder. The equivalent m.e.p. of the high-pressure cylinder added to the actual m.e.p. of the low-pressure cylinder gives the value of "m.e.p." that is to be used in the formula for computation of steam consumption when based upon a diagram taken from the low-pressure cylinder.

Proximate Determination of Feed Water—In an evaporative test in which an open exhaust-steam feed-water heater was employed, it was not practical to weigh the feed water after leaving the heater, though it was ascertained that 152,020 lb. of water was admitted to the feed-water heater at 80 deg. F. The water was heated to 200 deg. F. by exhaust steam at 2 lb. pressure. What weight of exhaust-steam condensate was added to the feed water? S. G. W.

A pound of exhaust steam at 2 lb. gage pressure, or about 2 + 15 = 17 lb. absolute, contains 1,153.1 B.t.u. above 32 deg. F., and in becoming reduced to water at 200 deg. F., or 200 — 32 = 168 deg. F. above 32, would part with 1,153.1 — 168 = 985.1 B.t.u. As the water admitted to the heater was raised in temperature through 200 — 80 = 120 deg. F., the heat received by the water was 152,020 × 120 = 18,242,400 B.t.u. Without allowing for any losses of heat from radiation, the heat gained by the water would be equal to the heat lost by the steam, and as each pound of steam condensed would part with 985.1 B.t.u., for the transfer of 18,242,400 B.t.u. there would be 18,242,400 ÷ 985.1 = 18,518 lb. of condensate added.

This method of determining the amount of water fed to a boiler is open to errors from inexactness in obtaining readings of water temperatures and the steam pressure, and also uncertainty as to the amount of condensation that may be due to radiation of heat from the feed-water heater.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Atmospheric, Vacuo-Vapor and Vacuum Heating Systems*

By James D. Hoffman†

SYNOPSIS—In the last 25 years steam pressures in radiators and coils have dropped from 50 or 60 pounds gage to atmospheric or below, and in some cases the return lines open directly to atmosphere. This article compares the relative advantages and points out the proper applications of heating systems using reduced-pressure returns.

The term "vacuum heating" may properly be applied to that class of heating systems having a continuous negative pressure within the return main, the pressure within the radiators being controlled by a thermostatic or float valve between the return main and the radiators. The vacuum may be produced by pumps, ejectors or condensers.

The advantages of such systems are: (1) Positive and easy return of the water of condensation. Negative effect of water and air pockets reduced to minimum. (2) Radiation at low levels drained with comparative ease by maintaining vacuum proportional to lift of water of condensation. (3) Return pipes of reduced size substituted for those of the ordinary gravity system, because of positive and rapid withdrawal of water of condensation. (4) Positive, continuous withdrawal from heating system of air with water of condensation. Heating medium circulates within radiators, eliminates short circuits and gives high efficiency of heating surface. (5) Adapted to the use of exhaust steam that has extra large air and water content. (6) Comparative freedom from pounding and water hammer.

The disadvantages are the small additional cost in maintaining the vacuum and the extra cost of installation and superintendence, particularly in small plants. Such systems of heating are usually installed in connection with lighting or power units where exhaust steam may be used in place of live steam. A diagrammatic view containing the principal apparatus involved is shown in Fig. 1.

HOW LIVE STEAM SUPPLEMENTS EXHAUST

Exhaust steam is delivered from the engines, pumps or other power apparatus to a receiver and thence to the heating system at a pressure of about five pounds gage. When the supply of exhaust steam is insufficient to maintain this pressure against the condensing capacity of the radiation, the pressure falls and enough live steam to maintain the required pressure is automatically admitted to the system through a pressure-reducing valve. The return line carries both condensation and air, and the pressure is atmospheric or below, the negative pressure being maintained just sufficient to insure a regular movement of the water of condensation in every line. Although the vacuum is supposed to extend only from the pump to the vacuum valve, it may extend to within the radiator if the vacuum valve is set for a constant discharge. Such an arrangement is not economical, since the latent heat of all the leakage steam is thrown away. Just before entering the vacuum pump the steam and vapor, mixed with the return water, are condensed by a spray of cold water. From the vacuum pump the returns are pumped to a feed-water heater and from this by a boiler-feed pump back to the boiler.

ONE-PIPE SYSTEM WITH SEPARATE RETURNS FOR AIR AND CONDENSATE

A modification of the mechanical vacuum systems known as the Paul system is shown in Fig. 2. This is a one-pipe system, which is usually fed from an overhead supply and drained to a wet return. The pump handles only water and does not create a vacuum in the return main. The vacuum in the air line, connecting with the air valves at the radiators, is produced by a steam, air or hydraulic ejector. The discharge may be directly into the atmosphere, into the atmospheric end of the exhaust heating main or into a secondary radiator where a separation is made, the water dropping to a receiver to be further used and the air exhausting to the atmosphere. For small plants having one-pipe complete-circuit system, the pump is omitted and the condensate flows direct to the boiler.

Closely associated with the two-pipe positive vacuum systems is a class of semi-positive two-pipe systems with vacuum assisting the gravity circulation. The pressures are approximately atmospheric throughout the radiators and the returns, and the latter open to the atmosphere through thermostatic or mercury traps near the boilers. The field of the semi-positive systems is the moderate-sized plant. They should be inexpensive in installation, automatic and continuous in operation and should require little personal supervision.

In the Moline system, Fig. 3, the vacuum in the return main is produced by a condenser (radiator or pipe coil) located above the end of the dry return, near the boiler. An inlet connection to the condenser is made from the steam supply through an ejector, which is in direct connection with the end of the return main. An outlet connection from the condenser leads to the main return below the water line of the boiler and to the air through a combined air trap and vacuum valve. This system presupposes a certain differential of pressure between the steam main and the return in order to operate the ejector. This differential may vary from one to three pounds, depending upon the capacity of the plant. The field of operation is general, applications being made to large as well as small plants. No automatic valves are used on the radiators, the return end having a key operated cutout.

Fig. 4 shows the mercury-seal system, in which the air is expelled from the radiators through thermostatic valves and is excluded by the mercury trap. During service the steam closes the thermostatic valves and is maintained at any desired pressure. Ordinarily in starting, the pressure is first raised to one or two pounds above atmosphere and held there for a while to expel the air, after which the plant is allowed to cool off, the vapor continuing to circulate until the pressure drops very low. The advantages claimed for this sys-

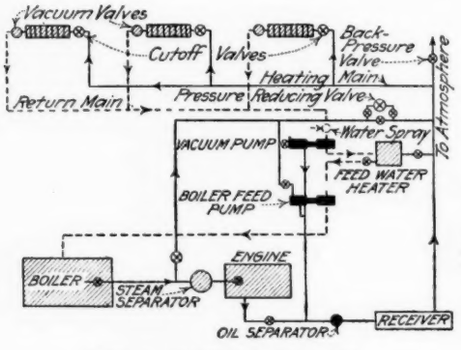


FIG. 1. VACUUM SYSTEM

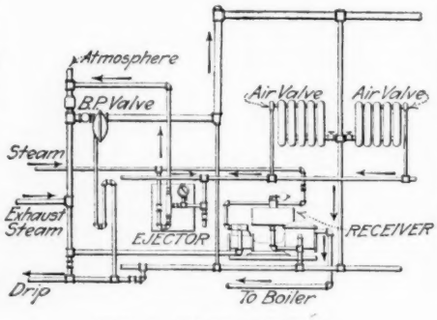


FIG. 2. PAUL SYSTEM

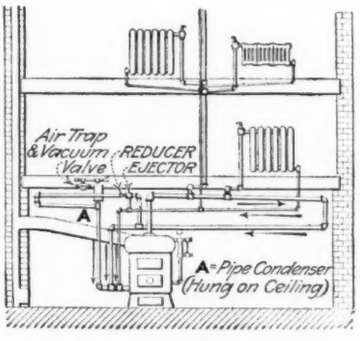


FIG. 3 MOLINE SYSTEM

*From a paper presented at the International Engineering Congress.

†Professor of Mechanical Engineering, University of Nebraska.

tem are: (1) Continuance of heat distribution over a greater portion of the twenty-four hour day; (2) greater flexibility for light as well as heavy service; (3) less frequent firing; (4) saving of fuel as circulation is obtained without raising pressure to atmosphere.

In this system the joints and fittings must be tight, otherwise when the steam pressure falls below atmosphere, there will be an inleakage, thus breaking and rendering the vacuum inoperative.

The differences between the vacuo-vapor and the atmospheric systems are not easily distinguished, yet the two-pipe type of radiator, the top supply and bottom return, the graduated steam supply and the return control seem to be especially characteristic of the latter class. The term atmospheric, as applied here, means that steam is maintained in the radiators, returns and other heating surfaces at approximately atmospheric pressure, regardless of the steam pressure in the boiler. To accomplish this the steam supply is controlled by graduated supply valves, and the return main opens directly to the atmosphere. The top connection to the radiator insures an easy displacement of the contained air to the returns, no air valves being used.

Heating systems of this class are simple and less expensive than the average steam system and, if properly installed, are noiseless. They are adapted to light or heavy service, since the graduated inlet valve may be set to fill from the full radiator or any part, as demanded. Regulation may be applied at the graduated inlet valve of the radiator, at the radiator outlet, at the atmospheric connection to the receiver, or at the bypass from the main to the return. Various combinations of these are made, from the simplest, where only the graduated inlet valve is used, to the most complicated, having a graduated inlet, a controlled outlet and a bypass or thermo-valve on the receiver. In the uncontrolled return the surplus steam from any radiator should not short-circuit to the returns of other radiators or waste to the atmosphere. This requirement suggests large radiators.

The atmospheric system, Fig. 5, has only the graduated supply, the radiators and returns opening direct to the atmosphere at A. A mercury pressure gage graduated to ounces and having a range of three pounds is used at B, either on the main or on a riser to a radiator. This gage is preferred to the steam gage at the boiler because of its accuracy in registering low pressures.

DISTINCTIVE FEATURES OF FITTINGS

The satisfactory working of vacuum, vacuo-vapor or atmospheric heating systems is largely dependent upon the fittings. A number of special fittings have been developed and sold to the trade as integral parts of the various systems.

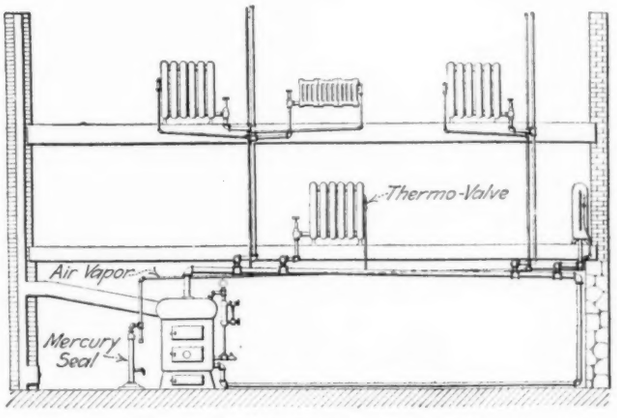


FIG. 4. MERCURY SEAL SYSTEM

They may be classified under four heads: 1. Supply valves—graduated to varying steam flow. Hand-operated and adjustable.

2. Thermostatic valves—those opening and closing under the action of heat. Automatic and adjustable.

3. Float valves—those opening and closing under the action of the buoyancy of the water of condensation. Automatic.

4. Nozzles—those having a constant opening and leakage. Nonadjustable.

Concerning the economic improvement that follows vacuum or vapor heating, many claims are made, some of which may be difficult to realize in practice. Estimates of saving range from 10 to 40 per cent. There is no doubt a saving due to the fact that the heat supply at the radiator may be graduated to suit the heat requirement of the room and thus avoid wastage by the opening of windows. But as the regulating device is principally controlled by the occupant of the room, the economy of the system is largely in his hands. The claim is made that a mechanical vacuum system using exhaust steam may serve as a condenser to the engine and improve the efficiency of the latter to a marked degree. This statement will be justified infrequently. The back pressure on the engine will seldom drop below atmosphere except when the vacuum return valves are given a constant leakage, when the loss in the latent heat of the steam may be

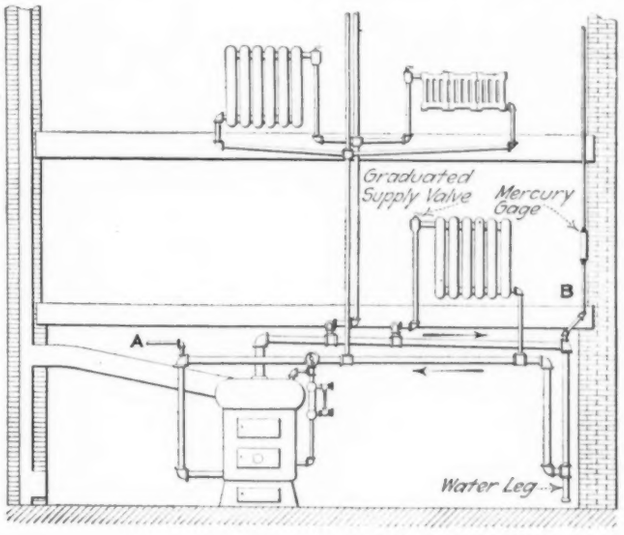


FIG. 5. ATMOSPHERIC SYSTEM

greater than gain derived from the increased mean effective pressure in the engine. The main economy lies in the use of exhaust steam as the heating medium. Exhaust steam at atmospheric pressure contains 85 to 90 per cent. of the total heat of the live steam entering the cylinder, heat wasted when exhausted to the atmosphere. The condensing engine saves only a small part, whereas the heating system may save all the heat in the exhaust. There is thus reason to look forward to many improvements in combined power and heating plants.

High steam pressures are now used only where a high temperature differential is required to minimize the heating surface. Very low pressures (high vacuum) are used only to the extent of overcoming a hydraulic head (in low-level radiation), except where the high vacuum is the result of air exclusion during condensation, in which case it means economy. Pressures near or at atmosphere are being increasingly used. Systems carrying such pressures are simple in construction, safe in operation, and when accompanied by a positive vacuum, may use either live or exhaust steam. Vacuum systems, as a rule, have better circulation, require smaller pipes, create less noise in operation and have better heat control than the standard gravity systems. They also eliminate the tolerated but much-disliked air valve. Vacuum heating, with its many variations, may therefore be considered a step in advance in the art of steam heating.

Most Important Nickel Steel

From an engineering standpoint the most important nickel steel is the low- and medium-carbon steel with 3 to 4 per cent. of nickel, commonly known as 3½-per cent. nickel steel. The presence of manganese in nickel steel is very essential, as it has a marked effect on the mechanical properties. The amount of manganse should range from 0.50 per cent. to 0.80 per cent. This steel has been extensively used since its introduction in 1889, and is a good all-round engineering and structural steel with considerably higher elastic limit and tensile strength than the corresponding carbon steel, and with practically the same degree of ductility.

The low-carbon steel, 0.10 to 0.20 per cent. carbon, is used extensively for case-hardening parts. It case-hardens more readily than carbon steel and gives a harder casing with a strong, tough, fibrous core. A great deal of nickel steel with carbon from 0.20 to 0.35 per cent. has been used in shapes and plates as rolled, and in annealed eye-bars for bridge construction. In this condition, which is not to be recommended for forgings, the following are typical physical properties: Elastic limit, 45,000 to 60,000 lb. per sq.in.; tensile strength,

80,000 to 100,000 lb. per sq.in.; elongation in 2 in., 20 per cent. to 15 per cent.; reduction of area, 40 per cent. to 25 per cent.

In a paper on alloy steels, presented to the International Engineering Congress, it was pointed out that annealed nickel-steel forgings have only a slight advantage in strength over carbon-steel, and consequently are not advantageous either from an engineering standpoint or commercially unless heat-treated. With heat-treatment nickel steel gives considerably higher strength than carbon steel, combined with greater ductility or toughness. It does not give as high values as the nickel-chromium and chromium-vanadium steels. Nickel steel rolls and forges readily and machines easily. It develops a very thick, hard scale which is apt to give considerable trouble in drop-forging and is hard on the dies. Nickel steel is also very apt to develop seaminess, especially when made in large heats and cast into large ingots, as is now customary. It requires a larger discard to insure soundness. The use of nickel steel in forgings, and particularly drop-forgings, is falling off in favor of other alloy steels with greater values.

Private vs. Purchased Power for Textile Mills*

By Frank W. Reynolds and Dan Adams

SYNOPSIS—Average rates for purchased power are higher by a small amount than the cost of generating power in a new isolated plant for a textile mill when there are no adverse conditions. The size of the plant and the load factor have little influence on the relative cost. A fair demand for steam in the process usually gives the isolated plant a decided advantage, but the use of steam for heating and for small demands is relatively unimportant. The saving from the use of exhaust steam is apt to be overestimated unless the diversity factor and variable demand are studied carefully.

The rivalry between the isolated plant and the central station has called forth many valuable and interesting papers, usually prepared by those most vitally interested either in the one or the other. The central-station advocate demonstrates that one kilowatt-hour in the central station will do the work of several in scattered small plants on account of the diversity in load; that the central station, besides requiring much less capacity, is also much cheaper per kilowatt-hour than a number of small stations; and that its operating efficiency is higher. On the other hand, some mill engineers, manufacturers and other defenders of isolated plants show that the economic advantage of concentrating power in a large station is largely offset by the cost of distribution and high overhead expenses. Also, every mill must have a steam plant for heating and to supply steam for manufacturing needs. Many specific cases and figures are cited to prove that when these factors are properly considered, manufactured power is cheaper than purchased power.

Both sides are presented with equal sincerity and plausibility, and the inquiring mill manager is left without solid foundation of fact upon which to base a decision. It is perhaps safe to state that it is difficult to prove the general proposition entirely in favor of one side or the other. Each case is a problem to be decided on its own merits.

Figs. 1 and 2 give the cost of purchased power for ordinary textile-mill conditions for any load up to 2,000 kw. These curves are plotted from the published schedules of public service corporations, one in New England and one in the Middle West. For comparison, the cost of private power has been plotted, using in each case the price of coal obtainable in the district served. The cost is for power delivered at the point of distribution at 550 volts in all cases. No provision is made for using steam other than for power, and where such use is considerable, the relative cost of private power may be much lower than given. While the cost of purchased power given is actual, the cost of private power is theoretical and is not intended to give more than an approximate and general comparison, but based on known conditions.

In an actual private plant the power cost often exceeds that given. The investment as stated is too low to cover any reserve or relay capacity, and therefore the reliability must be considered somewhat inferior to that of those central stations that were used for this comparison. Also, the investment will not take care of any disadvantageous conditions, such as expensive foundations or difficulty in obtaining condensing water; and no cost items are included for land or for coal in storage. The operating costs assumed, while no better than should be obtained, are really somewhat lower than the average. Nothing has been included for supervision other than plant labor, but this is usually legitimate expense.

*Presented at the annual meeting of the American Society of Mechanical Engineers, Dec. 7-10, 1915.

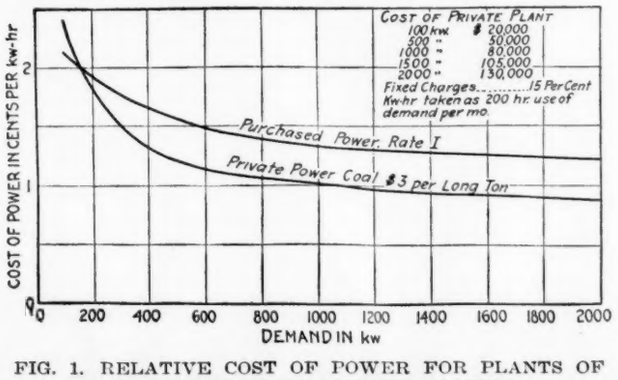


FIG. 1. RELATIVE COST OF POWER FOR PLANTS OF CAPACITIES UP TO 2,000 KW.—RATE I

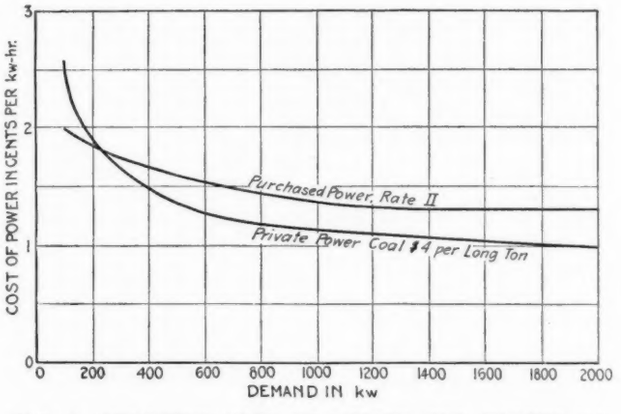


FIG. 2. RELATIVE COST OF POWER FOR PLANTS OF CAPACITIES UP TO 2,000 KW.—RATE II

The central-station rates quoted apply to any industrial plant. A textile-mill load is considered somewhat more favorable than the average industrial load on account of its demand. For this reason, special rates can be obtained in some localities, notably in the South, and to some extent in New England. Under these special rates, power usually costs about 1⅛c. per kw.-hr. for demands from 1,000 to 2,000 kw. and about 1c. above 2,000 kw. Such rates leave little financial inducement for the mill to build its own power plant.

Figs. 3 and 4 have been prepared from the same data as Figs. 1 and 2, to show the effect of load factor on the cost of power in the case of a 1,000-kw. demand. It will be seen that the curves for private and purchased power costs follow the same general direction. It appears, then, that load factor also has little effect on the relative cost of power.

There is a striking similarity between the curves shown for private and purchased power, both when the variable is the size of the demand and when it is the load factor. The inference is that these power rates were devised to compete with isolated plants rather than from actual costs, or desired rates, of the central-station power.

All that has preceded is a comparison of purchased and private power where the private plant is not yet built. But in the case of a going plant the purchase of power would save operating expense only and would not wipe out fixed charges on investment already made. Fig. 5 shows the cost of private and purchased power, as in Fig. 1, but without including fixed charges. The difference in cost is so great that it appears improbable that central stations can cause existing plants to shut down unless in the case of important changes or additions, or the necessary renewal of considerable apparatus, or because of extremely poor operating economy.

Every textile mill uses some steam for heating and manufacturing. This factor is of great importance, and should always be weighed accurately in considering purchased power.

In general, textile mills may be divided into two classes in this respect. The first contains those mills using only a relatively small amount of steam in manufacturing, and includes most silk and knitting mills and cotton and woolen mills not engaged in scouring, bleaching or finishing. Dye houses, finishing mills, print works and textile mills which finish their product are included in the second class, and have a large but variable demand for steam in the process.

Slashing may be taken as typical of a small demand for manufacturing steam. Often exhaust steam is used in this process. The pressure desired varies from 5 to 12 lb., which is a suitable pressure to bleed from an engine receiver or

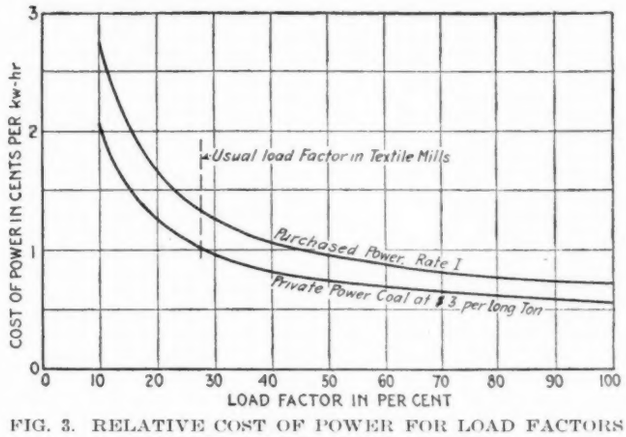

COST OF POWER IN CENTS PER kw-hr
LOAD FACTOR IN PER CENT
Usual load Factor in Textile Mills
Purchased Power, Rate I
Private Power Coal at $3 per long Ton
0
1
2
3
0 10 20 30 40 50 60 70 80 90 100

FIG. 3. RELATIVE COST OF POWER FOR LOAD FACTORS OF 10 TO 100 PER CENT.—RATE I

bleeder turbine. Only in rare cases would it be economical to run noncondensing apparatus to supply slashers on account of the high back-pressure required and the relatively small demand. In the case of a bleeder turbine, the saving in live steam amounts to about 30 to 40 per cent. of the steam bled. This saving is reduced by additional fixed charges on extra cost of turbine and exhaust piping, for a relatively small service, and, in a large plant with a long run of pipe, may be negative. For a rough figure, applicable to average conditions, the gross saving will be about $200 per year for each 1,000 lb. per hour bled, with coal at $4 per ton.

As regards steam for heating, there are two factors, often ignored, which militate against the use of exhaust in textile mills, especially in cotton and woolen mills. One is the large amount of heat liberated from the machinery during working hours and the second is the diversity in time between the use of power and the use of steam for heating. In a weaving mill in northern Massachusetts, where the power used per cubic foot of space is much less than in a balanced mill, the heating system was actually in operation only 25 hr. per week on an average during working hours of the heating season, or about one-fourth of the entire yearly operating time of the mill. Of course all heat used outside of working hours—nights and week ends—must be live steam. If exhaust is to be used the rest of the time, as a general rule it is proper to count on a demand only about one-half of the maximum, since the machinery provides the remainder, and this quantity probably will not be used more than 700 hr. per yr.

It appears, then, that the coal saving effected by using exhaust steam for heating and slashing is very small—smaller, in fact, than the unavoidable errors in estimating the total cost of power. There is, however, some further saving due to economy in investment. It is apparent from the foregoing that if steam for these demands is bled, the extra boiler capacity necessary to meet them is reduced approximately one-half. Also, it is cheaper to get this extra boiler capacity as part of a larger plant built for power generation than to provide it in a separate plant by itself, as would be necessary if power were purchased.

In textile work the reliability of power is usually more important than its cost. This is because power is a small item in the cost of manufacturing, whereas reliability affects the earning power of the whole mill. It is rather difficult to collect satisfying statistics on power reliability by each method of supply. One cotton mill buying power reports interruptions totaling 45 min. in five years. In this case the transmission line was less than half a mile long. Reports

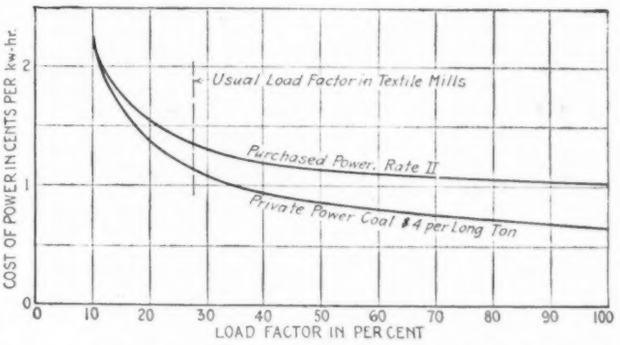

COST OF POWER IN CENTS PER kw-hr.
LOAD FACTOR IN PER CENT
Usual Load Factor in Textile Mills
Purchased Power, Rate II
Private Power Coal $4 per Long Ton
0
1
2
0 10 20 30 40 50 60 70 80 90 100

FIG. 4. RELATIVE COST OF POWER FOR LOAD FACTORS OF 10 TO 100 PER CENT.—RATE II

from several central stations give total interruptions on the individual lines ranging from 12 min. to 4 hr. per yr.

A hydro-electric company in the South, which sells to many mills, reports that interruptions of service to textile mills from all causes have averaged less than $\frac{1}{2}$ of 1 per cent. for the last nine years. Such records are doubtless better than the average.

The reliability of generation is usually better in a large central station than in an isolated plant, and especially when a number of stations are tied to the same system. On the other hand, an interruption of purchased power is more annoying than a shutdown in a private plant, because the management does not immediately know the cause or how long the power will be off. For this reason, purchased power is sometimes condemned as unreliable when the total interrupted time per year is small. An isolated plant with considerable relay capacity must, as a rule, be considered more reliable than purchased power. If the plant is small, however, the investment charges on this relay capacity add materially to the power cost, and few isolated plants carry spare apparatus.

Assuming that reliable power can be purchased at a cost approximating that of private power, it is not apparent that there are any attending disadvantages. There are, rather, many points in its favor.

The saving of investment for a power plant often is considered important, especially when that money can be invested to better advantage in the manufacturing plant.

Specialization in manufacture of product only is worth something. A considerable part of the effort of the engineer-

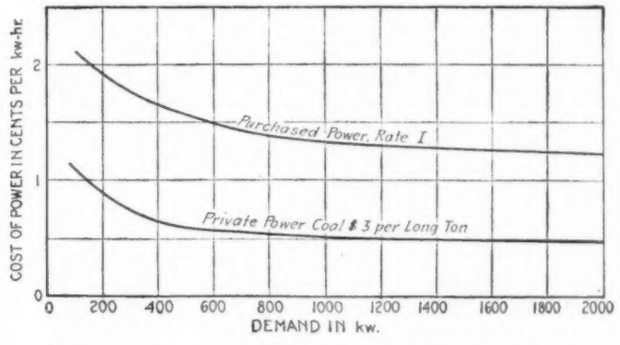

COST OF POWER IN CENTS PER kw-hr
DEMAND IN kw.
Purchased Power, Rate I
Private Power Coal $3 per Long Ton
0
1
2
0 200 400 600 800 1000 1200 1400 1600 1800 2000

FIG. 5. POWER COST WITHOUT FIXED CHARGES

ing department of a mill is devoted to keeping the power plant running efficiently. Where cost of power is only 2 or 3 per cent. of the cost of manufacturing, the services of the engineering department would probably be of greater value to the mill if devoted solely to keeping the producing machines running efficiently.

In the case of a new development subject to future growth, the central station offers a flexible source of power.

Where schedules for purchased power are published and intended to cover all conditions of use in industrial plants,

they are necessarily complicated, and some are unnecessarily complicated. Cases have been known where a manager has refused to buy power for the sole reason that to do so required him to sign a contract he could not understand. Conditions governing the use of power in textile mills are such that power companies often offer them special rates at a flat price per horsepower-year or per kilowatt-hour, with a guaranteed minimum. Such a contract would be received more favorably by the average mill man than one based on demand and monthly use of demand with various discounts, even though the final results were identical.

The following table from the 1910 United States Census shows the total and relative amounts of power purchased in the various textile industries, and also the total figures for all industries, for the year 1909.

POWER PURCHASED FOR TEXTILE MILLS

Industry	Total Hp. Used	Total Hp. Purchased	Per Cent. Purchased
Cotton goods, including small cotton wares.....	1,296,517	108,512	8.4
Hosiery and knit goods....	103,709	13,286	12.8
Silk and silk goods, including throwsters	97,947	10,354	10.6
Woolen, worsted and felt goods and wool hats.....	362,209	13,783	3.8
Total	1,860,382	145,935	7.8 Average
All industries	18,675,376	1,749,031	9.4

DISCUSSION OF THE PAPER

R. J. S. Piggott, in discussing the paper, was of the opinion that there is less chance for the small isolated plants to make good, as they are apt to employ low-grade men, and that the efficiency and reliability of the plant will thereby suffer. He also believed that to make a fair comparison between the isolated plant and the central station, the former should be credited with the proper reserve units, so as to afford a reserve capacity proportionately equal to that of the central station.

As the authors pointed out, there is very little use for exhaust steam in cotton mills, but Mr. Piggott believed it would be well for the owners of mills to investigate to see if they can remodel their processes so as to use low-pressure steam instead of the high-pressure steam now employed. Speaking of the plant with which he is connected, the Remington Arms, he stated that nearly all the steam put through the prime movers is employed in the works, either for industrial processes or for heating. He believes greater use could be made of the bleeder turbine, so that whatever steam is not used for heating or for industrial purposes can be conducted to a condenser and the benefit of high economy thus secured.

Charles S. Bigelow, speaking from experience with the textile plant in conjunction with a small electric railroad, which produced a wide variation in the load, believed that the bleeder turbine is helping to solve the problem of supplying a variable amount of exhaust steam. With regard to the use of high-pressure steam in industrial processes, he stated that it is temperature which is required rather than pressure, and that one solution to the problem might lie in superheating the exhaust steam to secure the necessary temperature.

The Seay Refrigeration System*

Instead of a separate generator and absorber as in the ordinary absorption machine, the two are combined in this system in the form of a cylinder containing a coil through which either steam or water can be passed, and this cylinder acts alternately as absorber and generator. In the installation of the plant three cylinders are provided to insure continuous working. The remainder of the plant consists of a condenser and refrigerator.

In this system there is no compressor with its accompanying engine, as in the vapor compression machine, and no feed pump with a steam cylinder, as in the ordinary absorption machine. The brine is passed through the refrigerator by a circulating pump and delivered in the measuring tank, from which it is dropped into a suction tank in which is placed a steam coil for raising the temperature of the brine.

In operation there is placed in the cylinder a salt that possesses the quality of combining with and liquefying large quantities of gaseous ammonia. This salt is available in unlimited quantity. Assume, therefore, that the salt and ammonia have been brought into contact and are in the cylinder in a liquid form. The next process is to apply heat, and this is done by allowing steam at a low pressure to pass through the coil in the cylinder, the effect being to drive the ammonia into the condenser, where it is liquefied and the salt returns to its natural and solid condition. After this first operation, and when the salt is returned to its original condition, steam is shut off and cold water passed through the coils. This causes the pressure in the cylinder to fall rapidly. Communication is then, at the proper moment, opened with the refrigerator, and some of the ammonia passes off as a gas and is absorbed by the salt in the cylinder. During this absorption cold is being produced in the refrigerator. When the salt has absorbed its full quantity of gas and has again become a liquid, the valve connection in the refrigerator is closed, steam is again turned into the coils, and the process is repeated.

In absorption machines as used at present, the ammonia is dissolved in water; it is in the use of the salt that the Seay system produces one of its many advantages. In both classes of machines we have liquid ammonia at a low pressure in the refrigerator, generating into vapor and so taking up heat from the surrounding brine. The amount of heat extracted from a pound of ammonia is nearly equal to the latent heat at the temperature of evaporation and may be taken to have a value of 530 B.t.u. This is the maximum possible amount of refrigeration per pound, and it is of course the same for all ammonia machines. In the Seay system the amount of heat spent is the quantity of heat used to drive off the ammonia from the substance with which it is dissolved. In both systems it will be seen that the ammonia before being heated is in the liquid form, and after being driven off is in the form of a gas. Each pound of ammonia must therefore receive an amount of heat equal to its latent heat at the temperature of evaporation. Considerable heat has to be supplied to separate the dissolved ammonia from the water in existing absorption machines.

Tests of the Seay process have shown the system to produce from 29 to 30½ tons of ice per ton of coal, on the basis of 9 lb. of steam per ton of coal.

Professor Knecht stated that he found no reason to fear that the salt would not act for an indefinite time. The liquid ammonia drawn from the plant after it had been in regular service for from two to five months was found to be quite free from sediment and dissolved substances, proving that no priming of the solutions could, therefore, have taken place in the cylinders.

In the discussion of the paper Dr. Ormandy said that the salt used in the Seay process was ammonium nitrate, which in normal times costs 6 or 8c. a pound. Relative to corrosion the doctor said that he had examined surfaces of the cylinders and coils after they had been in service for a year and found that there were no traces of corrosion. The coils are lined with aluminum.

*From the monthly bulletin of the Association Internationale du Froid.

U. of I. Plans Industrial Museum

The College of Engineering of the University of Illinois is to receive from the Commonwealth Edison Co. of Chicago, through the courtesy of its president, Samuel Insull, as a museum exhibit, a vertical triple-expansion engine with its direct-connected generators and their equipment of transformers, regulators, switches, instruments, etc. This engine, which was one of ten similar units, has a normal rating of 600 hp. and was built in the year 1893 by the Southwark Foundry and Machine Co., of Philadelphia. It was erected during the winter of 1893-94 in the Harrison Street power house. Direct-connected to the engine, one on each side, were two 200-kw. 150-volt direct-current generators, built by the General Electric Co. The Chicago Edison Co. later replaced these generators with the present double-current machines, which were among the first of this type of generator built. The unit was put in service Aug. 1, 1894.

The large size and the efficiency of its generating units (as these were at that time regarded) made the Harrison Street station celebrated for the character of its equipment and for its aggregation of power; but so rapid has been the increase in the size and efficiency of steam prime movers, accentuated in recent years by the advent of the steam turbine, that within ten years from the time that these engines were put into service they passed out of use because they were considered small, inefficient and inadequate.

The engine described will constitute an historical exhibit of high value. Its advent upon the campus will aid in accentuating a purpose frequently expressed by the trustees of the university—to develop an industrial museum in which shall be preserved such machines and mechanical devices as will serve to disclose to future generations something of the significant work that has been accomplished by those of our time. Once securely established, such a museum will year by year for an indefinite period draw to itself added material representative of its time.

Boiler-Room Practice at Warrior Ridge*

By J. C. Scholl

SYNOPSIS—Gives the results obtained by the use of carefully planned boiler-room methods and by the payment of bonuses to the boiler-room labor.

[The methods that produced the results described in this paper were instituted by Walter N. Polakov,[1] applied by him to the Warrior Ridge plant and fully described in a paper entitled "Task Setting for Firemen," presented before the December, 1912, meeting of the American Society of Mechanical Engineers, also published in *Power*, Dec. 23, 1913.—Editor.]

Several years ago the Penn Central Light and Power Co. began a study of boiler-room practice in an effort to increase the efficiency of its boilers and grates and reduce production costs. Tests were made of tools, materials and methods, and the best practice as determined by these tests was adopted as standard.

The experiments were made at the Warrior Ridge power plant, where the firing is done by hand. Many tests were conducted to determine, not the greatest amount of coal or ashes that could be handled by a man in an hour or a day, but the amount that he could handle regularly, without fatigue. In addition the proper weight and shape of tools, the correct amount of material to be lifted each time, the least tiring motions, the time required for each operation and the frequency of operations were determined.

As soon as the best methods and equipment were determined, written instructions were prepared covering the practice that had been found to produce the best results, and the proper tools were provided. Instruments were installed that enabled each man to see that proper conditions were maintained.

Then came the most difficult part of the task—the careful and patient drilling of each man in the correct performance of his task so that the same results would be secured the same way each time. The success of such training depends to so great an extent upon the willingness and the sustained interest of the worker that some plan had to be adopted for insuring this interest and coöperation. It was therefore decided to give each man a bonus every day that he carried out the written instructions and attained or exceeded the results that should follow the fulfillment of the prescribed methods. The success of the plan is most gratifying, for not only has the company saved expense, but the workers have reaped benefits in higher wages and better physical condition after the day's work.

Firemen are paid an extra 25 per cent. on their hourly rate, coal passers 2c. per ton besides their hourly rate of 25c. and ash handlers an extra 20 per cent. on their hourly rate of 21c. if the appointed task is accomplished.

The task of a fireman is accomplished if he complies with the following conditions: Maintains the efficiency of the boiler and grate at 70 per cent. or above for the coal that is standard at the time; carries steam pressure above 165 lb.; observes all rules and regulations of the management.

The task of coal passer is accomplished if he complies with the following conditions: Provides the firemen with all necessary coal without delay up to 60,000 lb. in 8.3 hr.; if his record is accurate, that is, if the total of the amount of coal shown on his report is within 2 per cent. of the quantity of coal deposited into the bin from which he passes the coal.

The task of an ash handler is accomplished if he complies with the following conditions: Lives up to the instruction card and completes all of the operations incidental to the operation of removing and disposing of ashes; takes proper care of his horse within the ten hours allotted. The quantity of ashes to be removed shall not exceed the amount accumulated from the combustion of 170,000 lb. of coal having not more than 12 per cent. of earthy matter and furnace refuse containing not more than 30 per cent. of combustible matter.

That there may be no misunderstanding between the workman and the management as to what is expected of the former, instruction cards are written containing directions as to the thickness of fire, amount of draft, water level, how and when to clean fires, when to use soot blowers, time for blowing boilers, etc. It must be understood that these things were determined after a most exhaustive series of experiments and tests which demonstrated the methods and materials that would produce the best all-around results. For example, the results of experiments with regard to the thickness of fuel bed and amount of draft have been reduced to figures shown on the dial of the steam-flow meters, which are in view of the fireman at all times.

If the steam-flow meter shows that the boiler is developing steam at the rate of 20,000 lb. per hr., the dial will indicate that the fireman must carry a draft equivalent to 0.6 in. of water and maintain his fire at a thickness of 8 in. On the other hand, should the steam-flow meter show that steam is being developed at the rate of 10,000 lb. per hr., then the draft should be equal to 0.3 in. of water and the fire should be 6 in. thick. The fireman is allowed 35 min. for cleaning fires under each boiler. When fires are being cleaned, the draft on that boiler is reduced and the draft on the others is increased accordingly.

All boilers are equipped with soot blowers, which are operated in accordance with written instructions three times daily—at 5:30 a.m., 12 noon and 5:30 p.m. Boilers are blown daily at 11:30 p.m.

The firemen work in eight-hour shifts and change shifts every two weeks. The head fireman receives 26c. per hr. with a bonus of 25 per cent., the earning of which is dependent upon all of the firemen earning a bonus.

The results obtained during ten average days at the Warrior Ridge plant under the system that has been described are shown in Table 1.

TABLE 1. RESULTS OF OPERATION FOR 10 AVERAGE DAYS

	Three Boilers
Heating surface, sq.ft.	6,000
Horsepower, manufacturers' rating	600
Horsepower developed	1,150
Horsepower developed above rating, per cent	91.8
Maximum horsepower developed 15 min. peak, per cent.	150
Temperature of escaping gases, deg. F.	490
Temperature of superheated steam, deg. F.	505
CO_2 (approx.), per cent	10.5
Apparent evaporation, lb.	8.907
Factor of evaporation	1.203
Equivalent evaporation, lb.	10.714
Efficiency of boilers and grate	72.5
Steam per kw.-hr., lb.	22.27
Coal per kw.-hr., lb.	2.5
Over-all efficiency, per cent	9.5
Cost per 1,000 lb. of steam dollars	0.0823
Cost per kw.-hr. of coal, dollars	0.00221
Average daily load factor, per cent	67.3
Pounds of coal banking per 1,000 sq.ft. heating surface per hour	26.3
Coal used, kind	Broad Top
Fixed carbon, per cent	77.12
Volatile, per cent	15.95
Ash, per cent	6.93
Moisture, per cent	1.20
Heat value, B.t.u.	14,350

The manner in which coal is selected may be of interest. It is not bought solely on the heat-unit basis or on volatile content, or on an ash basis, but because of its proved fitness for the service for which it is to be used, and the method is the same for all coals. It is tested both in the laboratory and under the boilers to determine the best results that it can produce. These results are shown in Table 2.

TABLE 2. RESULTS OF TESTS OF THREE KINDS OF COAL

	X Coal	Y Coal	Z Coal
Cost of coal per gross ton at mine, dollars	1.282	1.20	1.165
Freight to power plant, dollars	0.59	0.65	0.65
Cost of coal per gross ton at power plant, dollars	1.872	1.85	1.815
Cost of coal per lb., dollars	0.0008357	0.0008259	0.0008103
Average equivalent evaporation, lb.	8.511	8.497	9.404
Cost per 1,000 lb. steam, dollars	0.0984	0.0972	0.0802
Cost per 1,000,000 lb. steam (approx. a day's run of 50,000 kw.-hr.) dollars	98.40	97.20	86.20

During the progress of the test notes are made concerning the steaming qualities observed, the number of times it is

*Abstract of a paper read before the Pennsylvania Electric Association.

[1]Consulting Engineer, Stamford, Conn.

necessary to clean fires, the ease with which the coal spreads over the grates, the amount of attention necessary, etc. With such information it is easy to select the best coal.

When the kind of coal is changed it is necessary, of course, to make the proper modifications in the instructions and the basis upon which bonus is to be paid.

To obtain the results it is necessary that every part of the boiler-room equipment be well maintained and thoroughly clean.

A system of electric signals enables the switchboard operator to display before the fireman the load in kilowatts which must be carried. This changes constantly as the load varies. A whistle signal operated by compressed air enables the operator to summon the superintendent to the boiler room, engine room or switchboard gallery in case of emergency.

The success of the system in use in our power plant is dependent upon a spirit of coöperation between the management and the workmen. The management is compelled to accept its proper share of the responsibility and must keep in touch with the latest developments of boiler-room practice. Attention is given to suggestions made by the workmen, and if such suggestions are adopted an effort is made to give full credit to the originator of the idea. The workman's responsibility begins as soon as the standard has been established and is placed in proper form before him by the management. Too much stress cannot be laid upon the importance of following the instructions covering the workman's duties. Furthermore, rigid inspections must be made periodically by a duly authorized representative of the management to guard against any deviation from these instructions, so that there will be no danger of the practice being modified either arbitrarily or unconsciously by some unqualified person. Changes in the methods are made only after the receipt of definite written instructions conceling those in use.

The Principles and Systems of Electric-Motor Control*

By C. D. Knight

SYNOPSIS—Various forms of magnetic control in vogue today for both alternating- and direct-current motors are described.

The contactor, or magnet-operated switch, is the basic device of almost all automatic motor-control systems. Though motor- and solenoid-operated dial switches, liquid rheostats and other types of self-operated control mechanisms find certain specific applications, contactor control is the type generally employed, especially where severe service is demanded.

Contactor control is largely used with motors operating steel-mill machinery, ore bridges, large cranes, hoists of all kinds, reversing planers and other machine tools, printing presses, railway cars and locomotives, and in fact with almost all applications of the electric motor to intermittent duty where the burden of the service is thrown on the controlling apparatus. The essential and common parts of all contactors are contacts, blowout, magnet, frame and pivot bearings.

Experience has shown that the best practice is to use solid copper contacts on which the current is both carried and ruptured. They should close with a slight rolling motion to prevent the first rush of current from welding them together. Two heavy copper contact tips backed by a sufficient spring pressure will carry a surprising amount of current and furnish the best arc-rupturing means when placed under the influence of a suitable magnetic blowout. Carbon and other auxiliary contacts serve no really useful purpose on contactors which are subjected to severe and constant duty. In fact, they only complicate the construction of the device and add to the possible sources of trouble.

Laminated brushes for carrying current are also a source of trouble and can be profitably used only on contactors of such large capacity that the solid copper contacts will not carry the current. Large contactors (above 1,000 amperes) seldom operate as frequently as the smaller sizes.

The blowout coil is in series with the circuit through the main contacts, and the latter are between the poles of the blowout. This part of the contactor demands very careful design, as the instant suppression of the arc, forcing it out in the right direction and without injury to the insulation, is of prime importance in the life of the device.

The requirements as to the magnet are that it will, when energized, not only promptly and positively close the contacts, but will do this on a range of voltage which may be anywhere from 20 per cent. below to 10 per cent. above normal, for industrial work.

Direct-Current Shunt Contactor—This is operated by a magnet connected across the control circuit, which is usually the same as the circuit on which the motor operates. Shunt contactors are used as line contactors, also for accelerating, in which case they are brought into action by means of current-limit relays, time-limit relays or some kind of pilot controller. Shunt contactors provided with an adjustable air gap are used for accelerating, with their magnets connected across the motor terminals.

Series Contactors—These have a series coil only and are so designed that the contactor will hold open above a predetermined current setting and will close as soon as the current falls to or below that value. Series contactors are used for accelerating points on direct-current motor control. They cannot be used for partial speed control from a master controller, as their coils are in circuit with the armature of the motor.

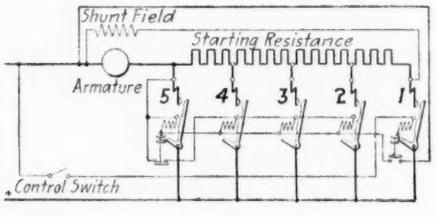


FIG. 1

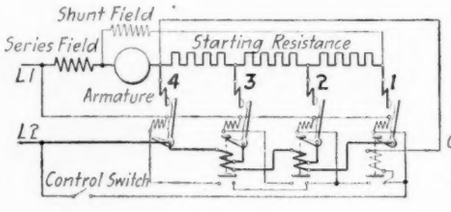


FIG. 2

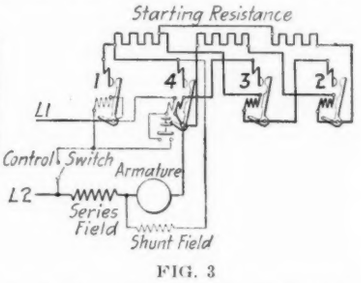


FIG. 3

Fig. 1—Counter E. M. F. method. Fig. 2—Current-limit control, series relays. Fig. 3—Current-limit control, series contactors

Alternating-Current Contactors—These are generally operated by a coil connected across the control circuit, which is usually taken from one phase of the circuit, if polyphase. On two- and three-phase circuits double-, triple- and four-pole contactors are used, energized in each case by a single magnet. For high-voltage service a potential transformer is used to reduce the voltage of the control circuit, as the coils cannot feasibly be designed to operate directly on voltages above 550. For automatic acceleration alternating-current contactors are connected electrically with current-limit or time-limit relays, which insure proper sequence and limit the rate at which the acceleration is accomplished.

For voltages exceeding 1,000, two types of contactors are used—either the air-break or the oil-immersed.

Air-break contactors have been developed for heavy duty, such as mine-hoist operation, for which in some cases they are called upon to operate once or even twice every two minutes under the most severe conditions. This type has been designed and operated up to 6,600 volts; for infrequent operation, oil-immersed contactors are in successful operation at potentials as high as 3,300 volts. Where employed on heavy-duty cycles, the carbonization of the oil is a great handicap, making it necessary to replace it frequently and adding greatly to the operating expense.

*From a paper before the American Institute of Electrical Engineers at New York, Dec. 10, 1915.

For direct-current motors, several methods of automatic control are used, as follows:

The counter-electromotive force method of control is more satisfactory for use with shunt than with series motors, because the counter-electromotive force of the latter depends upon the current as well as the speed, and it might be possible, if the motor is starting under heavy overload, to obtain sufficient counter-electromotive force to close all the contactors before the motor has had time to accelerate properly. The proper closing of the contactors used to short-circuit steps of starting resistance is accomplished by connecting the contactor coils in multiple across the armature, the contactors being adjusted to provide different air gaps between the core and the armature of the contactors in the open position.

As the motor accelerates, the contactor having the smallest air gap will close first, short-circuiting a portion of the resistance, which continues the acceleration of the motor. As the counter-electromotive force increases, the next contactor will close, and this is repeated until all the resistance is short-circuited. Sometimes, instead of adjusting the air gap between the core and armature, contactor coils are used that have different ampere-turns. A typical connection for counter-electromotive force control is shown in Fig. 1.

As the counter-electromotive force of a shunt motor varies directly with the speed for a given field strength, it is necessary that the speed be fairly constant in order that the contactors will operate properly.

There are two general methods of obtaining current-limit acceleration, the first using one or more current-limit relays which control the closing of accelerating contactors, and the second employing series contactors which combine within themselves the functions of current-limiting relay and accelerating contactor.

The first method, as generally used for direct-current motor control, depends on current-limiting relays, which may be mechanically connected to the contactors so that after the contactor closes, its relay is released for operation after the armature current has dropped to a predetermined value, due to acceleration of the motor; see Fig. 2.

Series contactors, so-called because the contactor-coil winding is in series with the motor armature, can be used only for the accelerating points, making it necessary to close the main circuit by a shunt-wound contactor, knife switch or the equivalent; see Fig. 3. This method has all the advantages of the current-limit relay scheme, using individual current-limit relays, and the wiring is much more simple.

For alternating-current motors, different methods of control are required, depending on the type of motor.

The proper starting current is obtained by reducing the primary voltage impressed on the motor, through a resistor or an auto-transformer. A resistor transforms the energy of the excess voltage required for starting the motor into heat while an auto-transformer acts as a step-down transformer with very little loss of energy. On the auto-transformer (compensator) are coils with several taps to give different starting-current values. Two coils are used for two-phase motors and two or three coils may be used for a three-phase motor. For automatic control using either a resistance or an auto-transformer, contactors are used for first connecting the motor to the line through the starting element, and after the motor has accelerated, the second contactor is closed, connecting the motor directly to the line. Fig. 4 shows the wiring of a resistance starter, and Fig. 5 that of an auto-transformer.

Slip-ring motors are started through a resistor connected to slip-rings on the motor shaft, which in turn are connected to the secondary circuits of the motor. The closing of the accelerating contactors which short-circuit the resistance in the secondary circuit is generally controlled by two or more current-limiting relays, except for small motors requiring only one step of resistance, where only one relay is necessary. Fig. 6 shows the connections of a four-point starting panel.

Another method sometimes employed for starting both direct- and alternating-current motors makes use of some form of time-element device for governing the time required for cutting the starting resistance out of circuit. This may be a solenoid-operated switch retarded by a dashpot or its equivalent, or it may be a motor-driven switch. For small- and medium-sized motors the switch will handle the motor current directly, and for large motors the switch is used as a master switch for energizing the coils of magnet switches or contactors. This method of starting is recommended for use with motors likely to be stalled or to become overloaded during the starting period. With the current-limit type of starter, the current would not fall to the point where the next accelerating contactor could close, but with a time-limit self-starter the fuses or circuit-breaker would open after the starting resistance had been cut out.

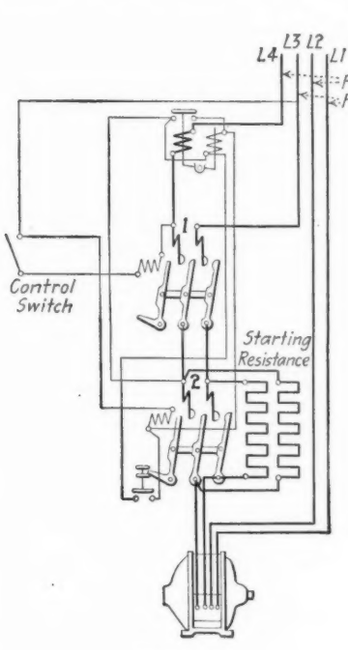


FIG. 4

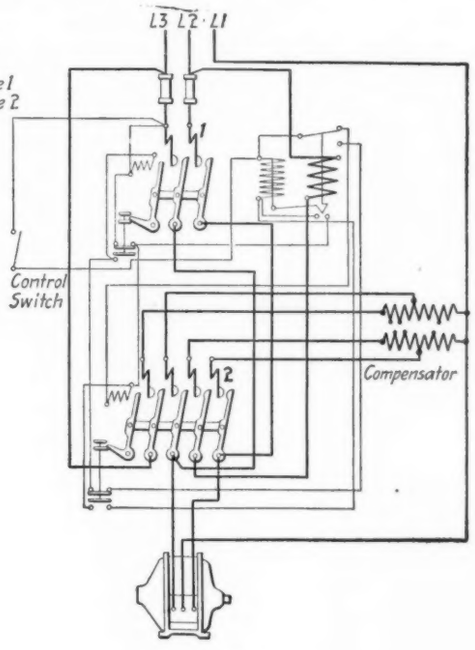


FIG. 5

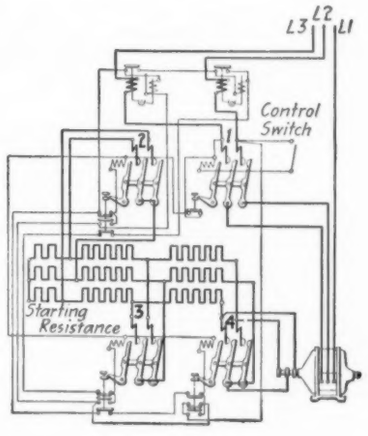


FIG. 6

Fig. 4—Resistance type self-starter for two-phase squirrel-cage motor. Fig. 5—Current-limit control of auto-transformer for three-phase motor. Fig. 6—Contactor panel for three-phase slip-ring motor

DYNAMIC BRAKING METHOD

One very important feature peculiar to the direct-current motor is the possibility of operating it as a generator for quick stopping or for limiting the lowering speed when overhauled by a suspended weight, as in crane service. For this purpose a resistor is connected in the armature circuit, and it dissipates the stored energy as heat. This method is called "dynamic braking."

For quickly stopping an alternating-current motor, use is sometimes made of a low-voltage direct-current circuit, which is connected to two of the primary phases after the motor has been disconnected from the line. The more usual method, called "plugging," is to reconnect the motor and apply power in the opposite direction, but the circuit must be opened as soon as the motor has stopped or it will run in the reverse direction.

Bids on Power-Plant Equipment

The following bids were submitted recently, by various manufacturers, for supplying the equipment named, entering into the new government central heating, lighting and power plant at Washington, D. C

Section B—To supply and erect two turbo-alternators, one turbo-exciter and one motor-driven exciter: General Electric Co., $105,000; Allis-Chalmers Co., $115,000.

The equipment specified consists of two turbine-driven 3,500-kw. three-phase 25-cycle 6,600-volt alternators and accessories, including considerable piping for steam, exhaust, water, oil and drips, pipe covering, etc. One of the 100-kw. 125-volt exciters is to be turbine-driven, and the other is to be driven by a three-phase alternating motor.

Section C—Two surface-condensing equipments for the two 3,500-kw. turbo-alternators. Five bidders—Westinghouse Electric and Manufacturing Co., $26,259 (low), to $33,875 (high).

Each condensing equipment is to consist of a horizontal surface condenser together with the necessary auxiliaries, steam, exhaust, water and other piping valves and covering capable of maintaining not less than 28.5 in. vacuum while condensing 52,500 lb. steam superheated, at the throttle of the turbine, 50 deg. F. above the temperature corresponding to 200 lb. steam pressure, temperature of water entering to be taken at 65 deg. F.

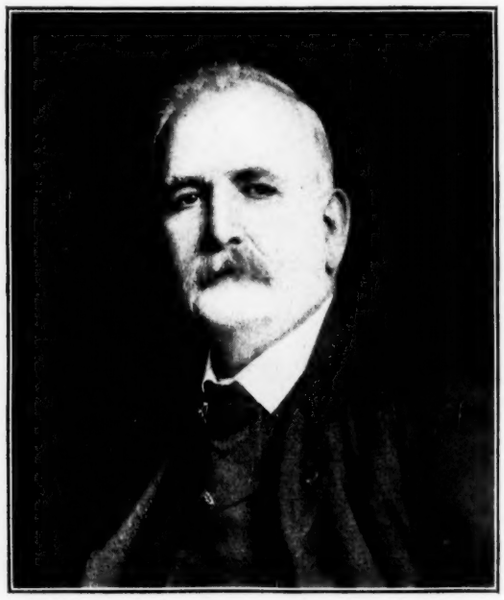
Section D—Six horizontal water-tube boilers with superheaters, ash hoppers, soot-blowing system, smoke uptakes, etc. Three bidders: E. Keeler Co., $111,900; Heine Safety Boiler Co., $112,873; Babcock & Wilcox Co., $129,007.

Section E—Six automatic underfeed stokers, forced-draft blowers and accessories. Four bidders—Combustion Engineering Co., $29,472 (low), to $43,130 (high).

OBITUARY

GEORGE D. ROLLINS

George D. Rollins, for several years general manager of the Holmes Metallic Packing Co., Wilkes-Barre, Penn., died at the Samaritan Hospital in Philadelphia, Dec. 16. He was born in West Townsend, Vt., Aug. 6, 1836, and attended school until he was 14 years old. Then he started to learn the machinist trade and attended night school at the same time.



GEORGE D. ROLLINS

Following the machinist trade until the Civil War broke out, he went to work for the United States Government in the government armory at Springfield, Mass. Later he was associated with the Smith & Wesson revolver factory for a number of years, then entered the machinery and supply business. In 1901 he became associated with the Holmes Metallic Packing Co., in which he held a large interest, and served as general manager until his death. He took out a number of valuable patents on metallic packing and other specialties during his connection with the Holmes company.

Mr. Rollins was a member of various Masonic bodies in Massachusetts, being a Knight Templar and thirty-second-degree Mason. He was also a member of the Odd Fellows, Red Men, and Travelers' Protective Association, and was the organizer of Post A, of Philadelphia. He is survived by a widow, one daughter and one son, Fred G. Rollins, who is president and principal owner of the Holmes Metallic Packing Co.

OLE N. TROOIEN

Ole N. Trooien, Brookings, S. D., died Dec. 21, 1915, at the age of 35. His "Steam Engine Investigations" thesis, written at the University of Wisconsin in 1907 attracted considerable international attention and is now largely incorporated in prominent mechanical-engineering handbooks. His illness began with an attack of the "bends" in 1908, while employed as an engineer in the construction of the Pennsylvania Hudson River tunnels.

ENGINEERING AFFAIRS

The National Gas Engine Association—The executive committee has selected Chicago as the city in which the eighth annual meeting will be held during the week beginning June 25, 1916. The officers are at work preparing a program which promises to be a most interesting one, and the standardization committee will make its report at this meeting, recommending for adoption several important changes in the industry.

Establishing and Maintaining Boiler-Room Economy is the title of a paper presented before the Ohio Society of Mechanical, Electrical and Steam Engineers by George H. Gibson, developing the thesis that the most important requisites to further improvements of boiler-plant economy are means of recording boiler performance. Information obtained sporadically, as by means of short boiler tests, is not so suitable for this purpose as information supplied continuously. The ways and means of attaining a certain standard of performance having been demonstrated, the management is in a position to ask for good results continuously, in fact standard rules of operation; that is, directions as to methods of handling fires, regulation of draft, blowing of soot, banking fires, carrying overloads, etc., can be written out, so that any man following instructions can obtain good results. The installation further arouses the pride of the engineer, and makes it possible to reward skill or attention to duty. This paper has been reprinted in pamphlet form by the Harrison Safety Boiler Works, Philadelphia, Penn., and is free.

NEW PUBLICATIONS

CONVERSION CHART. By M. R. Wolfard and C. K. Carpenter. Published by John Wiley & Sons, New York, 1915. Size, 12x34 in. Price, 25c.

A convenient chart embodying more than 40 conversions, among which are foot-pounds per second or per hour, British thermal units per second or per hour, to horsepower or kilowatts; metric to English units or power; miles per hour to kilometers per hour or feet per second; as well as linear, pressure, temperature and volumetric conversions.

PRINCIPLES OF DIRECT-CURRENT MACHINES. By Alexander S. Langsdorf, professor of electrical engineering at Washington University. Published by the McGraw-Hill Book Co., Inc., New York City. Cloth; 404 pages; 6x9 in.; 313 illustrations. Price, $3.

This book is an advanced treatment of the principles underlying the design and operation of direct-current generators and motors. The usual information is given regarding the laws of magnetism and the theory and construction of dynamos. Somewhat unusual is the attention paid to commutation and armature reaction. Three of the eleven chapters are devoted to a comprehensive and valuable outline of the theory underlying these subjects and to the methods of compensating for armature reaction and of improving commutation. Calculus is used freely in deriving the various formulas, although the author has endeavored to precede the mathematical analysis by a discussion of the physical facts.

In the chapters relating to operating characteristics of generators and motors, three-dimensional diagrams are used to show the relation between the speed, voltage and current. This method of graphical presentation might be necessary where there were actually three variables. In electrical ma-

chinery there are usually only two, and therefore the ordinary method of showing the relation between two variables seems much better. However, the book is written for junior and senior students of electrical engineering and should serve admirably for such a purpose.

HANDBOOK OF MATHEMATICS FOR ENGINEERS. By L. A. Waterbury, professor of civil engineering, University of Arizona. Published by John Wiley & Sons, Inc., New York City. Second edition. Leather, 213 pages; 3x5½ in.; 80 illustrations. Price, $1.50.

Professor Waterbury's "vest-pocket" collection of formulas, which was first published in 1908, is now presented in a second edition, with new sections on hydraulics and reinforced concrete. The sections in the first edition relating to algebra, trigonometry, differential and integral calculus, theoretical mechanics and mechanics of materials have been retained. Nearly half of the 200 pages are devoted to tables of logarithms and of trigonometrical functions. The book is especially useful as a portable reference for those who have studied the branches of mathematics it covers.

MECHANICAL EQUIPMENT OF FEDERAL BUILDINGS. By Nelson S. Thompson, chief mechanical and electrical engineer, office of the supervising architect. Third revised edition. Published by the New York Heating and Ventilating Co., 1123 Broadway, New York. Cloth; 6x9 in.; 400 pages. Price, $3.

The popularity of the previous editions is assurance that this one will be well received also. It comprises the latest practices in matters of design, and to some extent the operation, of the complete mechanical equipment of post offices, custom houses and all other public buildings coming under the office of the supervising architect of the Treasury Department and therefore occupies a position unique as the book of rules for the greater part of the government construction.

SAFETY ENGINEERING APPLIED TO SCAFFOLDS. Published by the Travelers Insurance Co., Hartford, Conn. Cloth; 6x9 in.; 354 pages; well illustrated. Price, $3.

As scaffolds of various kinds are so universally used wherever buildings and machinery are being erected and few, if any, other books treat the subject of their safe construction and use, especially as applied to distinctively American types, in anything approaching a comprehensive manner, the production of this book seems to be justified. The combined observations of a large staff of inspectors connected with the Travelers company in its varied activities constituted a veritable mine of information from which to compile the rules and instructions for the safe erection and maintenance of all sorts of scaffolds, platforms and the like.

EMPIRICAL DESIGN. By Leslie D. Hayes. Published by Carpenter & Co., Ithaca, N. Y. Size, 6¼x9⅜ in.; 105 pages. Price, $1.

This book reminds us of our student days, when we struggled with Unwin's "Elements of Machine Design," for like Unwin's, this book is designed to suit the needs of students in the scientific schools, being especially prepared for second-year students in the department of machine design at Cornell University, and comes in the college course ahead of the theoretical design. In fact, many of the data have been in use in this course at Sibley College and cover small machine parts, bolts and nuts, screws, keys, shafting and transmission members. As stated, it is especially adapted to the technical school and students' use.

BOILER ROOM ECONOMICS (Bulletin No. 2 of the Kansas State Agricultural College). By A. A. Potter and S. L. Simmering. Published and distributed by the Kansas State Agricultural College, Manhattan, Kan. Size, 6x9 in.; 55 pages; 49 tables. Free to citizens of Kansas.

The authors have collected data relative to performance, dimensions and costs, initial and maintenance, of the chief requirements of the boiler room, namely: Boilers; pumps and injectors; feed-water heaters and water-treating apparatus; stokers, economizers and superheaters. As expected in a booklet of this kind, the data are compiled from various recognized authorities. As there are 49 tables, some small of course, it may be judged that considerable information has been crowded into the 55 pages of the bulletin. The bulletin will surely be useful to those who have use for boiler-room equipment cost data. It is free to citizens of Kansas, and the Director uses his discretion about giving it to nonresidents.

MACHINE DESIGN. By Albert W. Smith and Guido H. Marx. Fourth edition. Published by John Wiley & Sons, Inc., New York City. Size, 5x9 in.; xii + 500 pages; 278 figures, 31 tables. Price, $3.

Machine designers will welcome this fourth edition, which has been revised and enlarged. Since Professor Smith is director of Sibley College, Cornell University, and Professor Marx is from Leland Stanford, Jr., University and much of the work on this fourth edition has been done by other Leland Stanford professors, it follows that this work is closely associated with the engineering courses in both universities. Special emphasis has been laid on the fundamental principles and methods of reasoning; and while a certain amount of machine design is said to be an inborn power, considerable assistance is always required from books.

Five general considerations are laid down as being of primary importance in the designing of a machine—adaptation, strength, economy, appearance and safety; and it is pointed out that while it is comparatively easy to design a machine that will work fairly satisfactorily for a short period, it is the machine that stands up under its work year in and year out that brings the real credit to the designer. Few machines are designed that do not in the course of their life go through a certain system of evolution; that is, one part breaks and is replaced by something stronger; one motion is too slow and is altered to give it the desired speed; accidents occur and it becomes necessary to add safeguards; or it may be that the whole machine is unnecessarily heavy, which increases its first cost, and competitors manufacturing lighter machines are getting the business. In such a case a new design must be made and the first cost of the machine reduced. In many cases appearance is of great importance. The beautiful lines of some of the modern automobiles have in many instances been the point which decided the customer which machine to buy; and while one may say this is an extreme case, it must be admitted that every purchaser of a machine is influenced more or less by attractive appearance. The successful designer is he who can look into the future and bring forth a machine that will not have to pass through an evolution.

It is presupposed that a person using this book has an ordinary university technical education, and in the preparation of this edition general engineering literature has been freely consulted, and many references are made to more exhaustive treatments on certain topics. The book is written solely for the machine designer and, like the former editions, will be welcome.

LOCOMOTIVE OPERATION AND TRAIN CONTROL. By Arthur Julius Wood, M. E. Published by the McGraw-Hill Book Co., Inc., 239 West 39th St., New York, N. Y. Cloth; 6x9 in.; 271 pages; 117 illustrations. Price, $3.

Although this volume is primarily for use in technical schools as a textbook, the engineer will find much of value regarding the theory on which are based certain problems in design and construction and concerning the recent developments in locomotive performance. The first two chapters deal with the fundamental principles of locomotive practice and with the classification and essential features of the principal types of locomotives.

The value of the book to the student and to the engineer that is not thoroughly conversant with the use of algebraic formulas is enhanced by the examples that are worked out, following the explanation and accompanying equations. A chapter is devoted to the acceleration of trains and to train resistance. The fundamental set forth underlie the theory of train operation. A general case is solved, and curves from tests are given.

New graphic methods applied to locomotive performance are dealt with in another chapter. Curves and formulas are incorporated, with the explanation of how to determine such problems as tractive force and resistance curves, unbalanced tractive effort, time-speed and time-distance curves.

Considerable space has been devoted to the operation and development of the air brake, with diagrams and results of tests; as is the case with other subjects treated, examples are worked out as a guide to the reader in solving the equations. The treatment of combustion and fuel economy naturally contains the same character of data as most textbooks in dealing with the subject, but they are put before the reader clearly. The treatment of the mechanical stoker is too limited to permit a thorough understanding of its operation. The subject of superheaters embraces the theory and advantages of superheat, its application and data of tests of superheated-steam locomotives.

The volume is well printed and the illustrations were evidently made for the purpose for which they are to be used, the volume being free from manufacturing cuts so frequently used to the detriment of any work of merit.

STEAM POWER. By W. E. Dalby, professor of engineering, University of London. Published by Longmans, Green & Co., New York. Cloth, 760 pages; 6x9 in.; 258 illustrations; 35 tables; indexed. Price, $6.

English technical books, particularly those relating to thermodynamics, have certain disadvantages when used by American readers. The most apparent is the system of units. Professor Dalby's massive volume, for instance, makes use of the pound-calorie rather than of the British thermal unit and consequently of the Centigrade rather than of the more familiar Fahrenheit temperature scale.

The book opens with an outline of the practical working of a steam plant, then goes on to explain how the power

developed can be measured, and afterward considers practical and theoretical thermodynamics and dynamics of the plant.

The author has chosen to divide the heat-carrying media into three interacting circuits: the heating circuit, dealing with the transformation of the fuel into gas and the work done by the latter; the motive-power circuit, in which the steam gives up its energy; and finally the so-called cooling circuit, where the water is circulated through the condensing system. The first five chapters are devoted to the consideration of these three circuits.

Chapter I gives a general description of the duties of the boiler, reciprocating engine, condenser and auxiliary apparatus forming the power plant. It also explains the meaning of such terms as indicated and brake horsepower, as well as the principle and construction of apparatus used in their measurement. The reader is next given an elementary conception of the method of calculating thermal efficiency and is shown by carefully prepared flow diagrams the heat-energy conditions in various steam plants.

The second chapter deals with the steam boiler. The principal elements of the construction of several English boilers are described, as also are safety valves, gages and other very English mountings. Particularly clear and useful are the sections relating to fuels and to the theory of combustion.

The third chapter is a 75-page review of the laws of thermodynamics. Advanced mathematics is used, but the steps passed through to obtain the formulas are given completely, an admirable and unusual method of presentation. Moreover, the working conclusions are brought out clearly for the benefit of those who do care to follow the mathematical discussion.

Chapter IV applies the theory to the performance of compound engines for both stationary and locomotive work, paying considerable attention to losses and to the means of reducing them. Concluding the part of the book concerned with heating, motive power and cooling circuits is a chapter on condensing apparatus, which seems all too short in view of the importance of the condenser and auxiliary apparatus in the operation of the modern power plant.

Chapters VI, VIII and IX relate chiefly to locomotive design and operation considered from a technical point of view. In the first are discussed the results of a number of locomotive tests made by Professor Goss in this country. The eighth chapter is on train movement and considers the rate at which energy must be spent to produce, maintain and destroy motion. The ninth chapter goes into the elementary mechanics of engine balancing and gives a number of graphic methods of obtaining the mass of the reciprocating parts. It also describes apparatus for the experimental study of balancing. This apparatus and, in fact, the whole chapter relate principally to the balancing of locomotives.

Chapters VII and X deal with engine mechanism, the first explaining the method of calculating and graphically determining turning couples and giving the theory of flywheels and governors. The tenth chapter relates to steam distribution and therefore to valves and valve mechanisms. The rectangular-valve diagram is used to illustrate a number of practical problems. The Reuleaux, Bilgram and Zeuner diagrams are explained, as are also typical locomotive valves, link and reversing motions.

The last hundred pages (Chapters XI and XII) are devoted to the steam turbine. After starting with the theory of steam flow and of nozzles and applying the theory to the steam jet in the vacuum-brake ejector and the boiler injector, the reader is introduced gradually to the principles underlying impulse and reaction turbines and to the general design of such apparatus. The construction of the Zoelly, Sturtevant, De Laval, A. E. G., Parsons and Curtis turbines is described somewhat briefly, mainly as used for ship propulsion.

Professor Dalby's treatise should prove exceedingly valuable to students, to engineers and, in fact, to anyone desiring a thorough and authoritative exposition of the principles, both thermodynamic and dynamic, on which the design and operation of steam-power apparatus depends. Original authorities, such as Newton, Carnot, Clausius and Lord Kelvin, have been consulted, and even the most advanced theory presented is at all times closely linked with fundamental principles. The author has not been niggardly in giving his authorities. In fact, he goes farther, so that the references to articles dealing with particular phases of the subject are in themselves a useful part of the book. Another pleasing feature is that the illustrations, instead of being photographic reproductions, are nearly all line drawings carefully prepared to explain and to amplify the text.

It would seem that more attention should have been paid to the apparatus in the stationary plant, although the author's purpose (to present the scientific principles involved in the industrial applications of steam power) has been most successfully accomplished. It is also to be regretted that steam-turbine valves and governors were not considered, but as it is, the book is almost of unwieldy proportions and no doubt some of these deficiencies were caused by lack of space. "Steam Power" is a most desirable reference work to those interested in a comprehensive treatment of the ground it covers.

STEAM AND PSYCHROMETRIC TABLES

A certain consulting engineer, having occasion to consult a steam table, asked the engineer of the hotel where he was staying if he had one, and was told that there was a whole bunch of them in the kitchen.

Most engineers, however, know and use their tables of the physical properties of steam, and many such tables are available. "Power" reviewed some time ago a set prepared by Prof. L. S. Marks for the Wheeler Condenser and Engineering Co., of Carteret, N. J., dealing with the properties of saturated steam at pressures principally below the atmospheric pressure. A copy of the third edition of these tables has just been received. Table 1 gives the properties for different vacua in inches of mercury from zero to 29.8; Table 2 gives the properties for each degree of temperature between 32 and 135 and for each fifth degree between 135 and 212; Table 3 gives the properties for each pound pressure between zero and 200 lb. gage. The pamphlet contains also illustrated instructions for measuring pressures by the mercury manometer or barometer, with a chart giving constants for correcting for the temperature of the mercury, with examples worked out; directions for correcting for the relative expansion of mercury and the brass scale with table; and tables for the reduction of barometric readings as affected by altitude and latitude to standard conditions.

A companion volume issued by the same company deals with "Psychrometric Tables for Cooling-Tower Work." The first 12 pages are devoted to a simple discussion of the purpose and use of the tables, with a chart giving the relations of relative humidity, saturation temperature, dry-bulb temperature, wet-bulb temperature and dew point. Table 1, covering 38 pages, gives, besides these relations, the weight or vapor in 1,000 cu.ft. of mixture for dry-bulb temperatures from 32 to 140 deg., all the practicable wet-bulb temperatures being given for each dry-bulb temperature. Table 2 gives the relation of dew point and weight of moisture per 100 lb. of air at 29.92 in. barometer. In conclusion, the sling psychrometer and its use are described. Both of these books may be had for the asking.

TRADE CATALOGS

P. W. Koebig, 116 Broad St., New York. Catalog C. Packings, leather belting, etc. Illustrated, 56 pp., 6x9 in.

The Foxboro Co., Foxboro, Mass. Bulletin No. 98. Recording gages for all purposes. Illustrated, 40 pp., 8x10½ in.

Tippett & Wood, Phillipsburg, N. J. Catalog. Water towers, stand pipes, etc. Illustrated, 62 pp., 5½x8½ in.

Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1097. Power transformers. Illustrated, 24 pp., 8x10½ in. Bulletin No. 1636. Hydraulic turbines and accessories. Illustrated, 56 pp., 8x10½ in.

Benjamin Electric Manufacturing Co., Chicago, Ill. Catalog B-21. Illuminating and wiring devices. Illustrated, 96 pp., 6x9 in.

Sherwood Manufacturing Co., Buffalo, N. Y. Catalog No. 17. Injectors, ejectors, oil pumps, oil cups, flue scrapers and blowers, etc. Illustrated, 62 pp., 6x9 in.

Quaker City Rubber Co., Philadelphia, Penn. Catalog. Packings, belting, hose, mechanical rubber goods. Illustrated, 180 pp., 6x9 in.

The Deane Steam Pump Co., 115 Broadway, New York. Bulletin D-184. High-pressure hydraulic power pumps. Illustrated, 24 pp., 6x9 in.

The Terry Steam Turbine Co., Hartford, Conn. Bulletin No. 20. "The Terry Turbine." Illustrated, 8 pp., 8½x11 in.

Wheeler Condenser and Engineering Co., Carteret, N. J. Pamphlet. "Steam Tables for Condenser Work." Thirty-two pages, 4x7 in. Pamphlet. "Psychrometric Tables for Cooling Tower Work." Fifty-six pages, 4x7 in.

Monarch Refillable Fuse Co., Inc., Buffalo, N. Y. Catalog No. 2. Refillable fuses, plugs, electric soldering irons, etc. Illustrated, 8 pp., 9x12 in.

The Wm. Powell Co., Cincinnati, Ohio. Booklet. White Star valves. Illustrated, 16 pp., 3½x6 in.

Armstrong Cork & Insulation Co., Pittsburgh, Penn. Catalog. Nonpareil corkboard insulation. Illustrated, 152 pp., 6x9 in.

Curious Stack Accident—A 14-ft. metal smoke-stack on a portable boiler fell upon the necks of two horses and instantly killed the animals at the Chicopee Falls, Mass., plant of the Fisk Rubber Co. on Jan. 4. The horses were hauling sand for the Fred T. Ley Construction Co., of Springfield, Mass., and at the time of the accident the driver had stopped his team in front of the boiler and had momentarily left his seat. The accident was caused by the failure of the stack guys.